CONSERVATION OF FOREST REMNANTS AND OTHER NATURAL FEATURES ON BELL HILL FARM SETTLEMENT, NORTH WESTLAND, NEW ZEALAND

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A thesis

Submitted in partial fulfilment

of the requirements for the degree

of

Master of Applied Science

in the

University of Canterbury

by

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Lincoln College

1981

Abstract of a thesis submitted in partial fulfillment of the requirements for the Degree of M. App. Sci.

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Two hundred and four forest remnants, several peat swamps and two induced pakihis on the Bell Hill Farm Settlement in North Westland have been surveyed and classified according to their nature conservation value. The study is part of an endeavour to incorporate nature conservation requirements into the farm development programme of the Department of Lands and Survey.

The land and biological resources of the Farm Settlement are described. Terraces and rolling hill country are the predominant landforms, underlain respectively by fluvioglacial outwash gravels and morainic till deposited by late Otiran glacial advances. There are small areas of alluvial terrace and of hill country underlain by late Tertiary sandstones and siltstones. The soils are gleyed and podzolised to various extents, reflecting the interaction over post-glacial time of the parent materials, the predominant mor-forming podocarp-hardwood forest vegetation, local topography, and the humid climate.

Before European settlement dense rimu-dominant forest predominated on the glacial terraces. Matai and kahikatea were dominant on the alluvial terraces, and mixed podocarp-hardwood forests covered the hill country. North Westland beech forests extended as far south as the Arnold River, and there were many beech outliers on the Farm Settlement. Most of the forests were destroyed or modified over a century of European settlement by timber milling and agricultural settlement. Twenty-one vegetation associations are identified in the remaining forest remnants, separated on the basis of landform, canopy species composition, and extent of human modification.

The formerly diverse avifauna in the district was reduced from 34 to 22 species during the settlement process. Bird species richness in individual remnants is now restricted, and is found to be directly related to area.

A scientific rationale for nature conservation is presented. Strategies of nature conservation are derived from consideration of its objectives and from empirical studies in island biogeography and population genetics. Scientific criteria for the selection and design of nature reserves include representativeness, naturalness, area, ecological diversity, rarity, ecological gradients, spatial distribution of and corridors between reserves, and buffer zones. Systems of nature conservation value assessment are described.

The richness and uniqueness of the New Zealand biota is outlined, and the high natural values of the former North Westland landscape are established. During the European period in North Westland there has been major modification of the natural landscape, particularly reduction of the lowland forests of the river valleys, hill country and coastal margins. The adequacy for nature conservation of the present system of ecological and scenic reserves in North Westland is assessed and is found to be wanting.

Forest associations in remnants on the Bell Hill Farm Settlement are shown to be poorly represented in existing regional reserves. A method of assessing the nature conservation value of the forest remnants is developed. Remnants are scored on four ecological criteria to produce an index and relative numerical assessment of their conservation value. The criteria selected are: regional community representativeness, and relationship to beech-podocarp boundary; area; degree of modification; and number of forest bird species.

The key factor in successfully integrating nature conservation with farm development on Bell Hill and other farm development blocks is identified as the management plan. General recommendations to minimise the impacts of farm development operations on forest remnants and other natural features are formulated. Reservation, retention as Crown land, and conservation covenants are identified as options for status and management of natural features after settlement.

Specific recommendations are made for the protection on the Bell Hill Farm Settlement of 59 forest remnants, two peat swamps of palynological significance, and an induced pakihi. Priorities are assigned to each recommendation. The recommendations include the establishment of two scenic reserves and the transfer of five remnants to existing adjacent reserves. An inventory summarising salient features of each remnant is appended.

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CHAPTER 1

INTRODUCTION

1.1 WEST COAST

The West Coast of the South Island consists of the counties of Buller, Inangahua, Grey and Westland, and occupies almost 10 percent of the total area of New Zealand. It is an elongated area extending from Kahurangi Point in the north to Jackson Head in the south.

Physically the West Coast is dominated by mountains, with substantial lowland areas only on the coastal plains and inland valleys of the larger rivers. It is almost completely isolated from the rest of the South Island, by the Southern Alps in the east and south, and the Tasman, Lyell and Victoria Ranges in the north. Main road connections are through the Lewis, Arthurs and Haast Passes. There is a rail link between Stillwater and Rolleston via the Otira tunnel.

The human population of the region is about 35 000 (Truman and Harrison, 1977). Agriculture, mining, and forestry are the major primary industries. Mining and timber milling have been the most important in the past but have been declining steadily in recent years. Farming appears to have the greatest growth potential in the future, and is likely to become the basis of the regional economy. An important contribution to this is the development by the Ministry of Agriculture and Fisheries and the Department of Lands and Survey of many of the presently unutilised or under-utilised pakihi lands. The Bell Hill Farm Settlement of the Lands and Survey Department is one of the foremost examples of this development.

1.2 BELL HILL FARM SETTLEMENT

The Bell Hill Farm Settlement is located within the Bell Hill, Kotuku and Kokiri districts near Moana, North Westland, New Zealand (Figs. 1,2 & 3). Moana is 26 km directly east-south-east of Greymouth, and about 35 km by road.

The Farm Settlement is owned and managed by the Department of Lands and Survey, principally to bring the land into agricultural

LOCALITY DIAGRAM

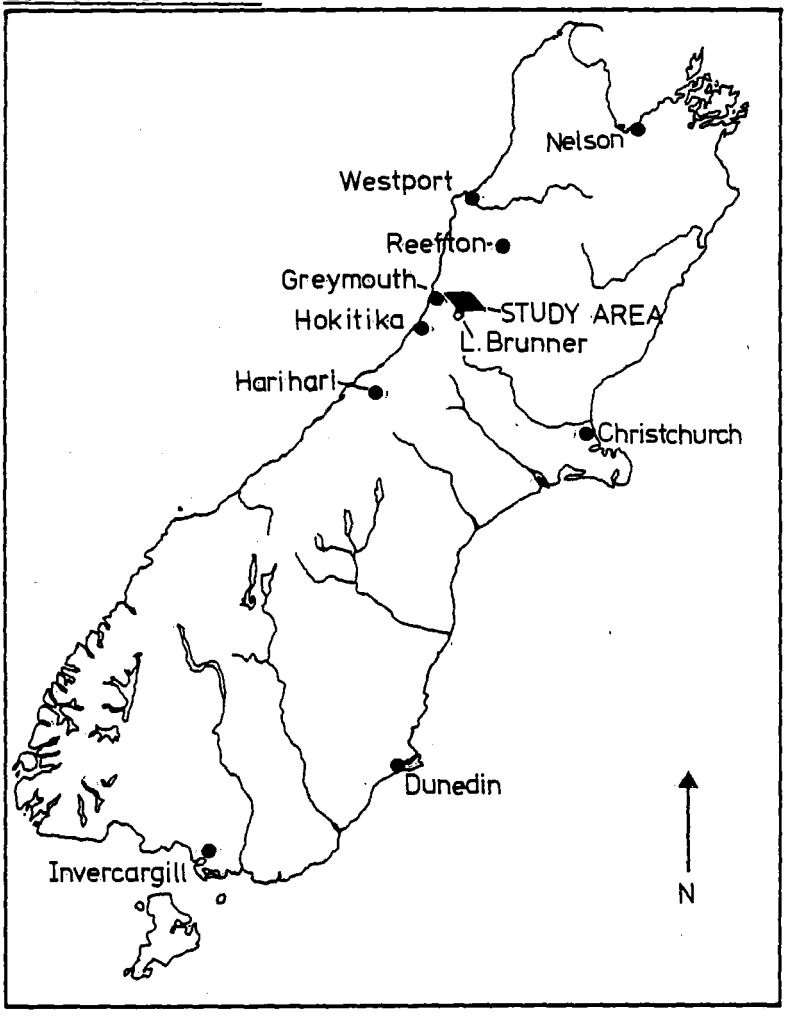

FIGURE 1: Locality Diagram

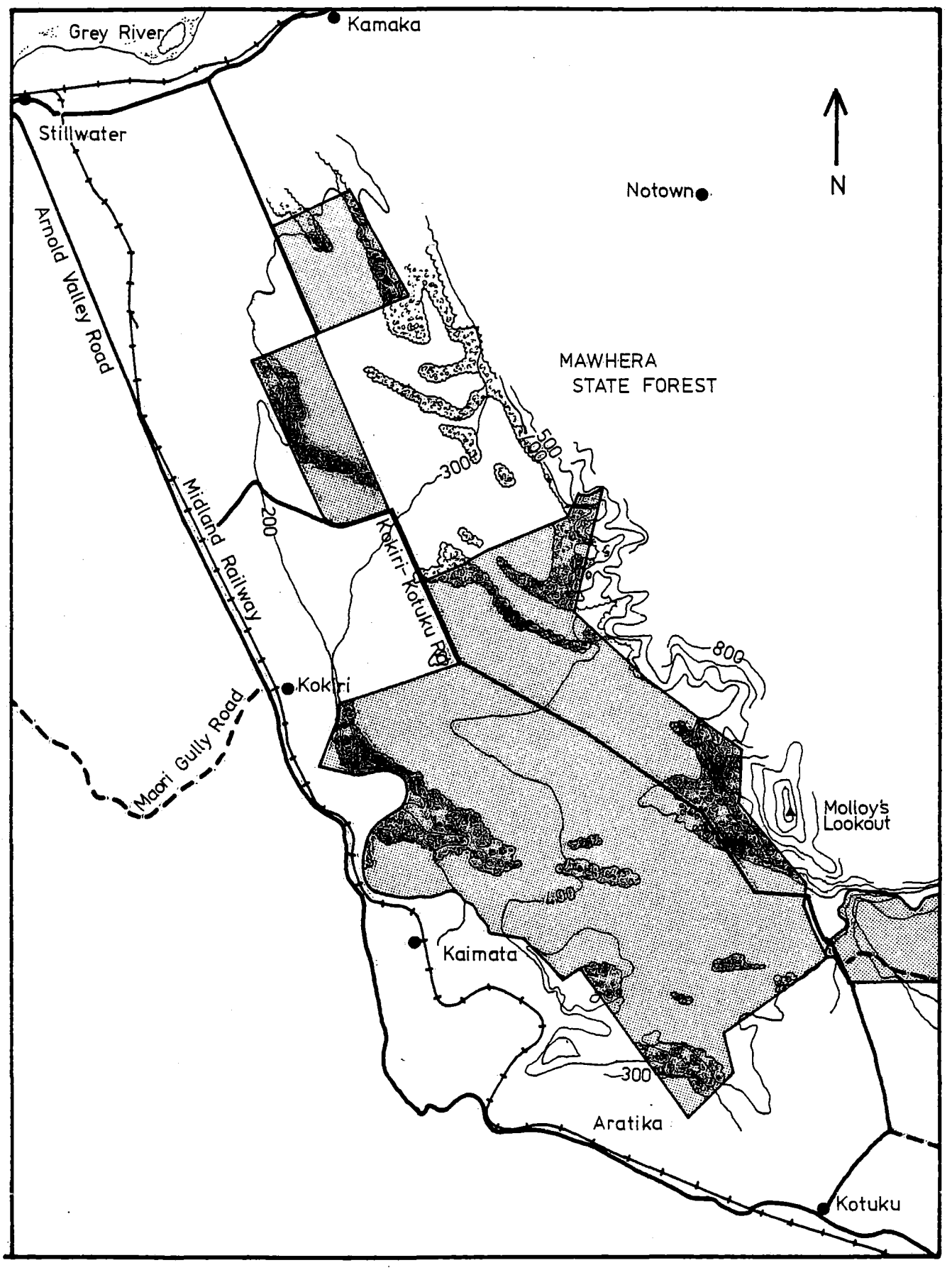

FIGURE 2: Topographical Map of Blairs Block (Scale 1:63 360).

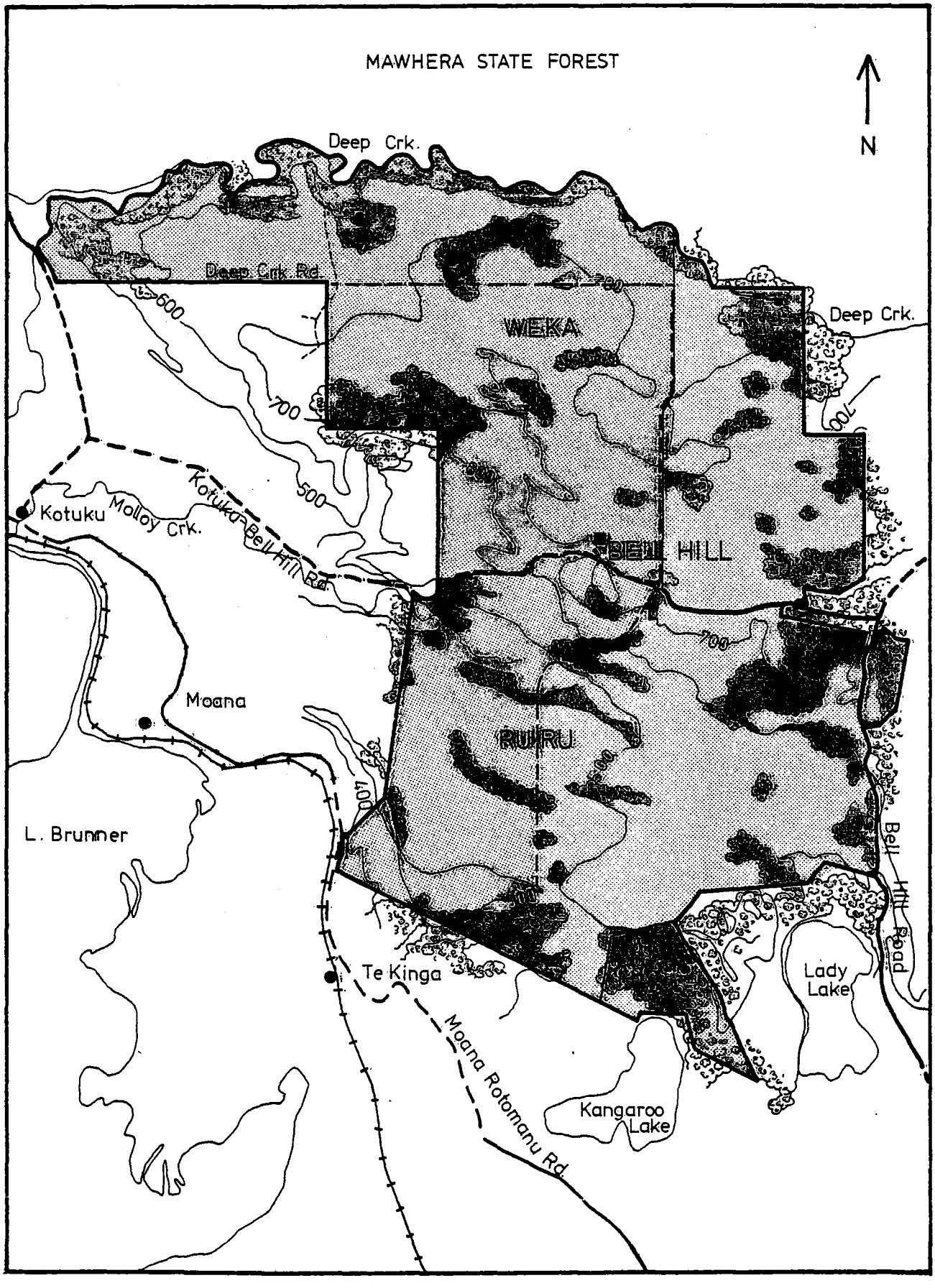

FIGURE 3: Topographical Map of Weka and Ruru Blocks (Scale 1:63 360).

production for eventual settlement of private farmers. The first 861 ha were acquired in 1957, a further 4600 ha in 1963, and smaller areas subsequently. It now has a total area of 6822 ha, and is managed as three blocks: Blairs block (2143 ha) in the Arnold Valley, and Weka (1970 ha) and Ruru (2709 ha) blocks north-east of Moana (Figs. 4 & 5).

The Department has pioneered development techniques on the difficult pakihi soils, principally using aerial oversowing and topdressing. The Farm Settlement is now the largest farming enterprise on the West Coast. Tentative proposals are to subdivide it into 14 sheep and beef units and 3 dairy units upon settlement (Austin, 1980).

1.3 PURPOSE OF STUDY

Before European settlement, the Farm Settlement and surrounding region were clothed principally in dense podocarp and podocarp-hardwood rainforest. This was largely cleared about the turn of the century by milling and subsequent burning for agricultural development. The remnants of this massive forest clearance have since been slowly reduced by further milling and clearance, and at the present time only about 1200 ha remain.

Though small in size, these remnants could be important for biological conservation as well as for scenic and historical purposes. They are particularly valuable in representing the forest vegetation of the younger glacial surfaces which have been widely cleared in North Westland. The Farm Settlement is also astride the beech-podocarp boundary in North Westland, an ecotone which is important in the study of vegetation history during and since the Otira glaciation.

During the early stages of development on the Farm Settlement, many forest remnants were further modified by inappropriate fencing, clearing of small areas, and stock grazing. More recently, the policy of the Lands and Survey Department has been to protect and fence off significant forest areas (although this practice has not extended to the large areas of successional shrublands[1]). However there has been no systematic survey to assess and rank the scientific and other values of forest remnants and to determine priorities for protection.

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1. The term "shrublands" is used throughout this text in preference to "scrub". "Scrub" has a strong connotation of worthless, which is frequently not the case. Hence its use is avoided.

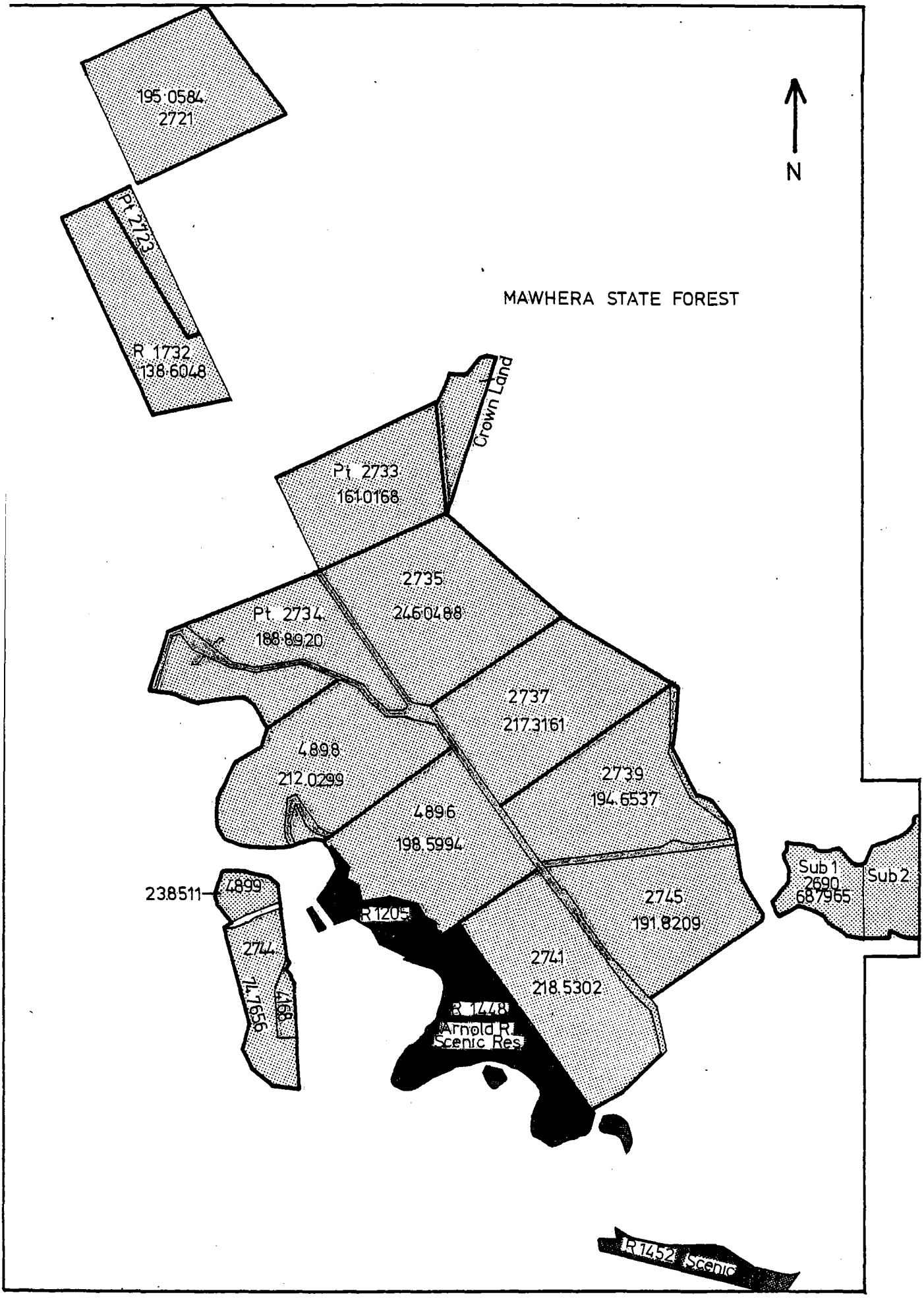

FIGURE 4: Cadastral Map of Blairs Block (Scale 1:50 000).

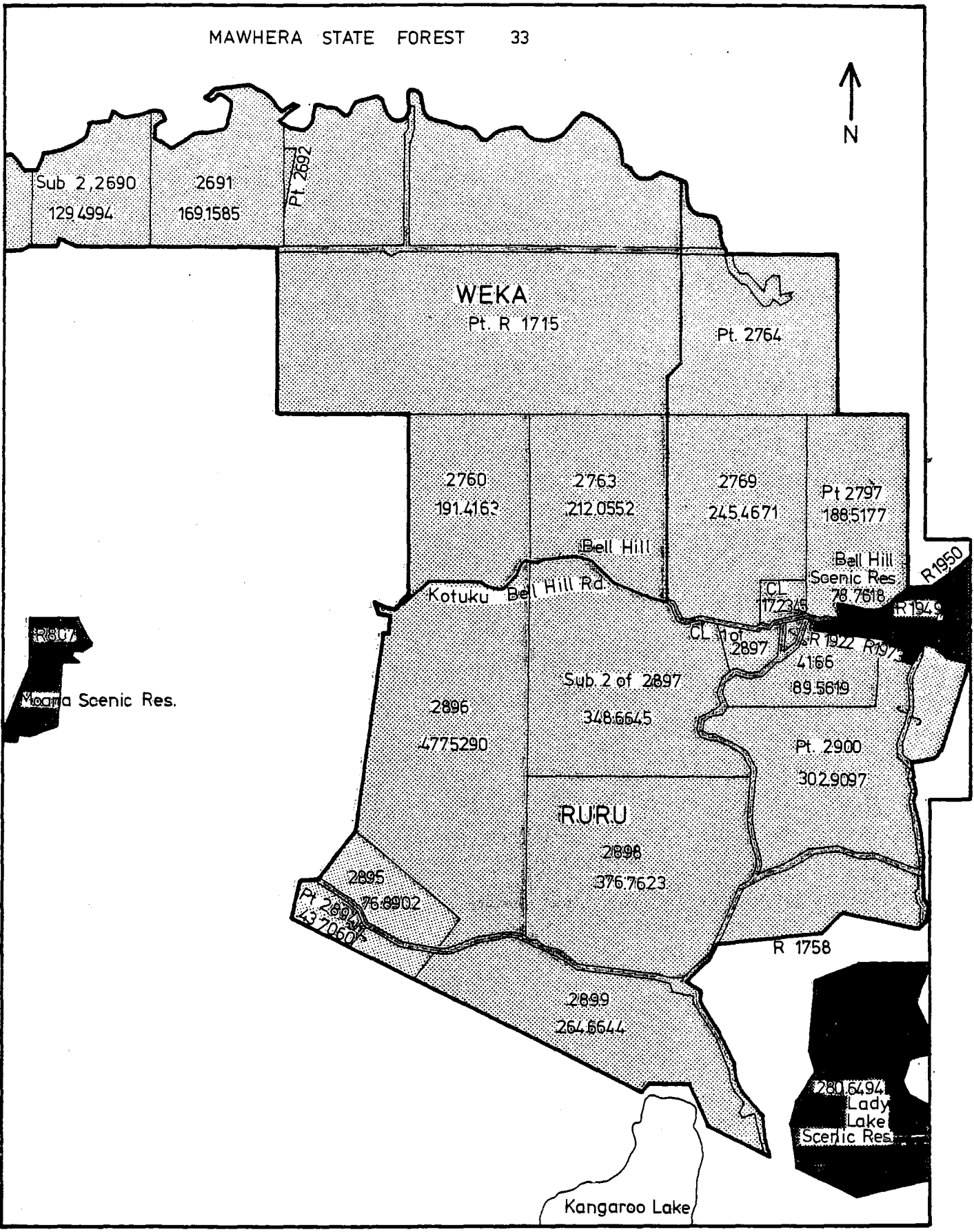

FIGURE 5: Cadastral Map of Weka and Ruru Blocks (Scale 1:50 000).

This study is a report on a systematic ecological survey of the forest remnants of the Farm Settlement, and an assessment of their value for conservation. The principal purpose has been to identify and rank areas of conservation value, so that they may be accorded appropriate priority in protection. All forest remnants have some value however, and their protection within the land development and settlement process is also discussed.

The study is in three main parts. The first introduces the natural history and natural features of the Farm Settlement. The second presents a rationale for conservation, and a method based on ecological criteria for assessing and ranking the conservation value of forest remnants on the Farm Settlement. The third part discusses ways and means of protecting natural features on farm development blocks generally, and recommends specific protection measures for features on the Bell Hill Farm Settlement.

Field work was carried out from January to May 1979, and between 18 June and 12 July 1980.

It should be borne in mind that this report has been written to meet the requirements of both a thesis for the degree of Master of Applied Science at Lincoln College and a working document for use by the Department of Lands and Survey.

1.4 NOTE REGARDING PLACE NAMES

Place names in the Farm Settlement region can be confusing. References to "Bell Hill" may apply to the Bell Hill Farm Settlement, the former Bell Hill township, or to a hill named Bell Hill. The following names are used throughout this text.

a. Bell Hill (town) - site of former Bell Hill township and sawmill. The mill, which was abandoned in the 1930's, was situated on the Bell Hill Road about 1.5 km south of the Ngahere - Haupiri Junction Road. The site lies several kilometres north-east of the Bell Hill Farm Settlement, and is now marked by a few farm houses only. It is not shown on Fig. 3.

b. Bell Hill Farm Settlement - consists of Blairs, Weka and Ruru blocks (Figs. 2 and 3), and herein is often abbreviated to "the Farm Settlement". "Bell Hill" on Fig. 3 refers to the Farm Settlement.

c. Bell Hill - prominent bell-shaped hill, 840 m (2750 ft) high to the east of the Farm Settlement (S52: 107746). It is not shown on Fig. 3.

d. Bell Hill Scenic Reserve - a 78.5 ha scenic reserve adjacent to Ruru block, located about the junction of the Kotuku-Bell Hill Road and the Bell Hill Road.

e. Bell Hill road runs from Inchbonnie to Rotomanu to the Ngahere - Haupiri Junction Road. The road is shown on Fig. 3.

North Westland in this text refers to the land between the Taramakau River in the south and the Nelson - Westland Land District boundary in the north. It roughly corresponds to the area of Grey County and Grey Borough, and excludes central Westland between the Taramakau and Waitaha Rivers.

All map references are to N.Z.M.S. 1 (1: 63 360) topographical maps, and are of the standard form.

CHAPTER 2

RESOURCE INVENTORY

2.1 CLIMATE

Although New Zealand climate is governed by a procession of low troughs and anticyclones moving regularly across the Tasman sea from Australia, its detailed character is determined largely by its long narrow outline and varied topography. In the South Island, the Southern Alps present an effective barrier to the prevailing rain-bearing westerly winds, and are responsible for the characteristic humid climate of the West Coast. The climate, however, is notable for other features, including small temperature ranges, mild winters, and cool summers, and comparatively high number of sunshine hours (Garnier, 1958).

The high rainfall is fairly evenly distributed throughout the year. Mean rainfall at Greymouth over the period 1941-1970 is shown in Table 1.

Rainfall is normally brought by north or northwest winds, plus some showers brought by southwesterlies. There is an increasing rainfall gradient from north to south, and a strong altitudinal gradient from the coast to the mountains. Mean annual precipitation at Franz Josef for example is 5130 mm (N.Z. Meteorological Service, 1979), and annual falls up to 12 500 mm have been recorded in the Southern Alps (A. Bell, 1979). Rainfall also varies locally according to topography. At Reefton, in the rain shadow of the Paparoa Range, mean annual rainfall is only 2016 mm (N.Z. Meteorological Service, ibid.). Though the number of rain days is not significantly higher than elsewhere in New Zealand, heavy falls may be expected. On average more than 1 cm of rain falls on each rainy day, and daily falls of 5-8 cm are common.

Despite the high rainfall, the amount of bright sunshine is comparatively high with an annual average of 1709 hours being recorded at Greymouth. Summers are generally cool and winters mild, temperatures vaying little throughout the year. The mean annual temperature at Greymouth is 12.0°C. The large inland valleys, such as the Grey and Buller, are separated from direct oceanic influences and are subject

TABLE 1: Mean Monthly and Annual Rainfall at Greymouth 1941-1970 (mm)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
198	203	193	216	224	196	193	191	201	224	236	213	2488

(Source: N.Z. Meteorological Service, 1979)

to a greater temperature range. During settled weather, cold easterly katabatic winds may drain overnight from the Southern Alps. Ground frosts are common during winter, with an annual average of 79.7 days at Totara Flat, contrasting with only 16.8 days on the coast at Greymouth. Fog may occur on the coast and early morning fog is common in the Grey Valley, especially around Reefton. Relative humidity is high, generally averaging greater than 80 percent during most of the year. Mean wind speeds are low because the prevailing westerly airstreams are blocked by the Southern Alps, but occasional southeasterly gales may occur in exposed valleys.

Climatic data for the Farm Settlement area is limited. The nearest climate stations are at Greymouth and Totara Flat (26 km north-west and 31 km north-north-east of Moana respectively), but oceanic and rainshadow influences there may cause significantly different weather patterns. From rainfall isohyets, mean annual rainfall on the Farm Settlement is within the 2800-3200 mm range, with a slight positive gradient towards the east. Mean annual temperature and number of days with frost are likely to be comparable with those at Totara Flat further north in the Grey Valley, where the figures are 11.1°C and 79.7 days respectively. Snow may fall on the lowlands during winter. A light dusting was recorded on 10 July 1980.

2.2. GEOLOGY

2.2.1 Geological History of North Westland

The following account of geological history is based largely on Nathan (1978).

2.2.1.1 Pre-Cretaceous. The early geological history of the North Westland region is complex and not fully expounded. Geological structure and patterns in the region proper are markedly different from those of greywacke and schist of the Southern Alps across the Alpine Fault to the east (Fig. 6). Some of New Zealand's oldest rocks occur in the region. They include the Greenland and Waiuta groups, marine sedimentary rocks composed of largely unfossiliferous, strongly indurated, green-grey greywacke and argillite, derived from granitic rocks. Fossils recently found in Waiuta greywacke in the Waitahu valley near Reefton, in greywacke morainic

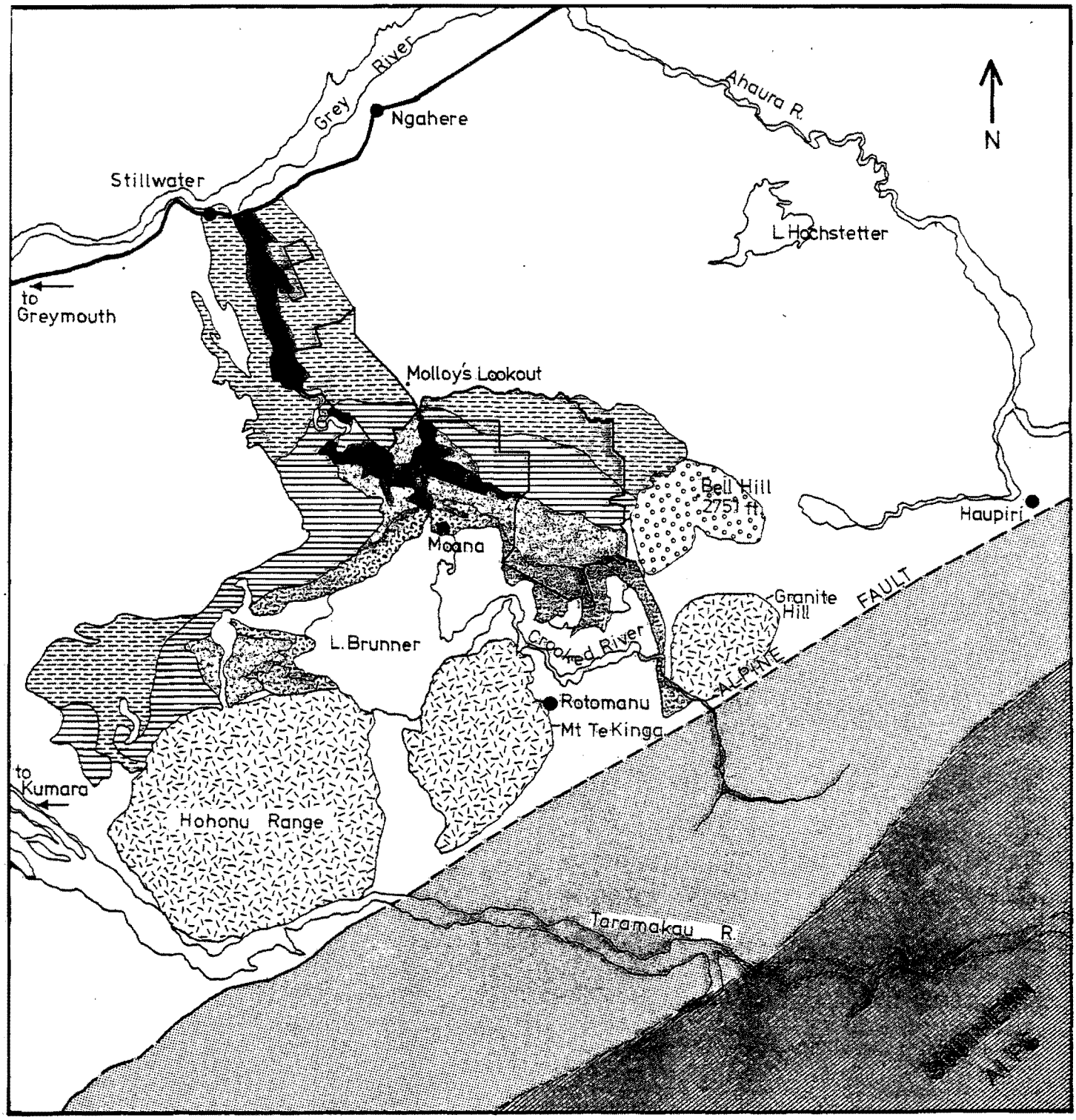

FIGURE 6: Geological Map of Bell Hill Farm Settlement and North Westland Region (Scale 1:250 000). (Base maps from Bowen (1964), Warren (1967) and Gregg (1967).)

debris west of Lake Haupiri, and elsewhere apparently indicate an early Ordovician age (Nathan, 1979; Gage, 1980). The Waiuta group occurs at Bell Hill and the Greenland group along the flanks of the Hohonu Range. Together with early Palaeozoic intrusive Tūhua granites (as at Granite Hill), it forms basement rock over much of the area west of the Alpine Fault.

2.2.1.2 Cretaceous to Lower Quaternary. Later geological history is better known. West of the Alpine Fault, there is a break in the geological record between Greenland Group and Upper Cretaceous sediments, but from Upper Cretaceous to Lower Quaternary a complete sedimentary sequence is preserved.

Between the Upper Cretaceous and the Oligocene, major sediment deposition occurred in the Paparoa geosyncline, a rapidly subsiding trough in the area now occupied by the Paparoa Range. The Paparoa and Brunner coal measures of the Greymouth coalfields were deposited at this time, followed during the early Tertiary by marine sandstones, mudstones and limestones of the Island Sandstone, Kaiata Mudstone and Cobden Limestone formations.

The Paparoa geosyncline began to rise slowly during the early Miocene, a movement which continued subsequently and culminated during the Kaikoura Orogeny in the formation of the present Paparoa Range. Much of the Tertiary sedimentary deposits on the Range has since been removed by erosion. Simultaneously a new depositional basin, the Grey Valley geosyncline, began to form east of the Paparoa geosyncline approximately along the line of the present Grey Valley syncline. This has been subsiding ever since, and corresponds to the present Grey-Inangahua depression. In the late Tertiary widespread submergence led to deposition of soft sandstone, mudstone and siltstone sediments derived from erosion of the developing Paparoa Range to the west and new land ridges to the east. During the early Pleistocene these were buried under a thick layer of Old Man Gravels, consisting of greywacke, schist and scattered granite boulders derived largely from rapid erosion of the rising Southern Alps under glacial conditions to the east.

The extent of deposition over the period is shown by a bore sunk at Notown in 1944 which passed through over 2000 m of late Tertiary sediments.

2.2.1.3 Late Quaternary. The late Quaternary period was characterised by extensive glacial phases and continued rapid growth of the Southern Alps to the east. These processes combined produced a vast amount of erosional material and subsequent deposition of moraines and aggradational fluvioglacial terraces downstream. Glaciers descending from the Alps occupied the upper reaches of the Taramakau, Ahaura and Grey valleys during the main glaciations (Suggate, 1965).

The detailed history of glaciations and interglaciations is still unclear (Burrows, 1978; Stevens, 1980). Conventionally it was thought there were at least four glacial stages, the Porikan, Waimungan, Waimean and Otiran, followed by the Waiwheran, Terangian, Oturian and Aranuian interglacials respectively. However evidence from drilling of deep-sea sediments suggests that there were as many as 20 glacial periods in the last two million years (Stevens, 1980). Sufficient detail is known of the Otira glaciation to show the occurrence of warm periods or interstadials (Moar and Suggate, 1973).

The glaciers have largely fashioned the present landscape of the main river valleys. There is a repeated pattern of extensive aggradational outwash surfaces downstream from terminal moraines, and often of lateral moraines upstream. Lake Brunner, and Lady and Kangaroo Lakes occupy scoured-out hollows exposed following glacial retreat. The last major retreat of the glaciers began about 14 000 years ago. Slow shaping of the landscape has continued since, but without major alteration to the basic pattern left at the end of the glaciations.

2.2.2 Geology of Bell Hill Farm Settlement

Apart from small areas of Tertiary hill country on Blairs block and minor aggradational and degradational alluvial terraces, glacial moraines and fluvioglacial outwash terraces of Otiran age entirely cover the Farm Settlement area (Fig. 6). The moraines are characterised by a high percentage of large sub-rounded boulders and fine sediments, and the outwash surfaces are underlain by stratified gravels. Both moraines and outwash terraces consist primarily of schists and greywacke sandstones derived from the Southern Alps, with some granites. They were deposited during the final two phases of the Otira glaciation by the northern and north-eastern lobes

of the Taramakau glacier, and have been mapped by the 1:250 000 Geological Survey (Gregg, 1964; Bowen, 1964; Warren, 1967) as the Loopline and Moana formations, occurring respectively 22 300-18 000 years BP[1] and 17 000-14 000 years BP (Suggate and Moar, 1970). Nathan (1978), when mapping the Greymouth region (including Blairs block) at a scale of 1:63 360, subdivided the Loopline formation into two advances, Loopline-1 (older) and Loopline-2 (younger), a division based on Suggate (1965). The Loopline-2 was the greatest ice advance of the late Otira glaciation.

On Blairs block the terminal moraine of the Loopline-1 advance (in the south-east part of the block immediately west of Molloys Lookout) and the gravel outwash surface downstream were overtopped by the later Loopline-2 advance. Only a small area of low moraine ridges and adjacent outwash terrace has been mapped by Nathan (1978) as Loopline-1 formation[2]. Most of the block consists of gravels and sands underlying an aggradational fluvioglacial outwash terrace of the Loopline-2 formation, sloping gradually down the valley from about 200 m above sea-level in the south-east to about 30 m near the Grey River. Parts of this terrace are mapped as swamp deposits, but these have been transferred directly from the N.Z.M.S. 1 topographical map (S44) (Nathan, 1979) and are at most only superficial. Loopline-2 morainic ridges and slopes are present in the south-east of the block. A small area along Piper Creek is mapped as Moana aggradational terrace, but in fact may be a Loopline-2 degradational terrace (Nathan, 1979). Two small gullies in the north-west corner of the Block are also Loopline-2 degradational surfaces.

On Ruru and Weka blocks, four major geological formations are mapped by the 1:250 000 Geological Survey (Fig. 6). In the north, a Loopline aggradational outwash terrace slopes gently down towards Deep Creek from the extensive Loopline morainic deposits in the centre of the two blocks. The moraine rises from about 160 m to 300 m above sea level, covers a belt up to 3-4 km wide, and slopes gently to moderately steeply down from its peak towards the south or south-west.

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1. BP = Before Present (taken as 1950)
2. However his mapping of the boundaries between the Loopline-1 and Loopline-2 formations on Blairs block is unclear.

The southern part of Ruru block is principally a gravel and sand aggradational outwash terrace of the younger Moana formation. It is about 160 m a.s.l. and has a slight downward slope to the south or south-west. On its eastern edge there is a series of small moraines and terraces which may indicate a phased withdrawal of the ice. The fourth formation, along the southern edge of Ruru block, is the upper part of the Moana moraine. It falls moderately steeply southwards towards Lady and Kangaroo Lakes.

Geological mapping at a 1:63 360 scale is presently unavailable for Ruru and Weka blocks. It is likely however that the two Loopline morainic and associated outwash formations mapped by the 1:250 000 survey in the vicinity correlate with the Loopline-1 and Loopline-2 formations on Blairs block (D. Bell, 1979). The older Loopline-1 moraine lies outside the Farm Settlement on the north side of Deep Creek. The Loopline moraine and outwash surface on Ruru and Weka blocks are of the Loopline-2 formation, deposited between 22 000 and 18 000 years ago (Suggate and Moar, 1970).

2.2.3 Kotuku Oilfield

The oil seepages near Kotuku are the largest known natural surface occurrence of petroleum in New Zealand (Wellman, 1971). Oil and gas seepages occur in the vicinity of Deep Creek about 2 km above the Arnold River, and also in the Deep Creek gorge above the Notown (Kokiri)-Kotuku Road bridge (Fig. 6). More than 40 wells have been drilled in the past, including two at Kotuku and Aratika in 1977 and 1978 and one at Kokiri in 1980 as part of a Government oil exploration programme. None has produced appreciable quantities of oil or gas. Only two early bores are known to have been sunk within the boundaries of the present Farm Settlement. Much has been learnt about underlying geological structures from the intensive drilling. Drilling logs record a partly eroded sequence of Tertiary deposition between surface alluvial and glacial deposits and basement slate, along the faulted Kotuku anticline. A more detailed account is given by Wellman (1971).

2.3 TOPOGRAPHY

The Farm Settlement is located on the lowlands of the Arnold and Grey River valleys. The land is of low relief, consisting of

little-dissected morainic hill country and flat to gently sloping glacial outwash terraces between 30 and 260 m above sea level. Four major geologically controlled topographical units are recognisable, the Loopline-2 and Moana outwash terraces, and the corresponding morainic hill country formations. Each of these has its characteristic patterns of geology, soils and vegetation, and may be regarded as a distinct land system (Speight, 1968).

(a) Loopline-2 Outwash Terrace

This fluvioglacial aggradational terrace covers most of Blairs block, and the northern part of Ruru and Weka blocks. On Ruru and Weka blocks, the terrace slopes gently northwards towards Deep Creek. It is little-dissected, and ranges in altitude between about 200-260 m a.s.l. On Blairs block the terrace is relatively flat, bar a small cliff face in the centre, and has a slight north-westerly aspect. It is dissected by a number of small streams, of which Piper Creek and Candlelight Creek are the largest. There are some low morainic ridges in the south-east, corresponding to Loopline-1 morainic deposits.

(b) Loopline-2 Morainic Hill Country

Loopline-2 morainic hill country occurs on the southern part of Weka block, the centre of Ruru block and the south-east of Blairs block. The moraine wall falls from about 300 m a.s.l. at its peak on Weka block to about 130-200 m where it meets the Moana outwash terrace in the south of Ruru block and to about 90 m on Blairs block. The land has a southerly, south-westerly or south-easterly aspect, is of gentle to moderately steep slope, and is slightly dissected. Large and small boulders are present at the surface.

(c) Moana Outwash Terrace

This fluvioglacial outwash terrace covers most of the southern part of Ruru block. It is mainly flat, although in the east there is a sequence of small moraines and terraces. It is slightly dissected by small tributaries of Molloys Creek. There is a small remnant of this terrace on the south-east of Blairs block near the Arnold River.

(d) Moana Morainic Hill Country

This occurs along the southern edge of Ruru block, where the moraine falls from about 175 m a.s.l. down to about 130 m at Kangaroo Lake. Aspect is southerly, and slopes are gentle to moderately steep.

Additionally, two topographic entities of small area on the Farm Settlement may be recognised as land systems at a scale and degree of detail similar to that by which the above four land systems are differentiated.

(e) Tertiary Hill Country

Two parts of Blairs block abut onto hill country in Mawhera forest to the north. The land is hilly and dissected, and underlain by soft late Tertiary sandstones and mudstones of the Wanganui Series (Bowen, 1964).

(f) Alluvial Terraces

There is a degradational terrace cut into the Loopline-2 outwash terrace along Deep Creek, on the northern edge of Ruru and Weka blocks. The terrace is wider and deeper to the west, and is incised over 40 m at the western end above the Deep Creek gorge. Smaller alluvial degradational terraces occur elsewhere on the Loopline-2 and Moana outwash terraces, such as those along Piper Creek and the tributaries of Molloys Creek. There is a small area of the Arnold River alluvial terrace on Blairs block.

Prominent topographic features of the area around the Farm Settlement include: Bell Hill (840 m) to the east; Mt Alexander (1960 m) and the Alexander Range to the southeast; Mt Te Kinga (1230 m) to the south; the Hohonu Range (1100-1300 m) to the south-west; the southern end of the Paparoa Range (*c.* 1000 m) to the west; and the low Tertiary hill country and old glacial landforms in Mawhera forest to the north. Lake Brunner (Moana), 84 m a.s.l. and of 4120 ha, lies at the base of Mt Te Kinga and the Hohonu Range.

2.4 SOILS

2.4.1 Soils of North Westland

In North Westland there is a diverse and complex pattern of soils which vary according to the degree of action and interaction of the five soil forming factors: climate, parent material, organisms, relief and time.

The soils can be subdivided into seven main groups: recent soils on river flats; yellow-brown sands on coastal dunes; yellow-brown earths on terraces, rolling land and hill country, with associated soils on steeplands; gley soils, mainly on terraces; gley podzols on terrace remnants, generally at intermediate or high levels; true podzols on rolling moraine and terrace margins and ridges; and organic soils in depressions and swamps (Mew and Leamy, 1977).

2.4.2 Soils of Bell Hill Farm Settlement

The soil parent materials are mainly morainic and fluvioglacial deposits, consisting of greywackes and schists derived from the Southern Alps, and some granites. Loess-like material (Stevens, 1968b) has been recorded on older terraces elsewhere in North Westland, but probably does not occur on the low-level terraces and moraines of the Farm Settlement (Young, 1967). On the Tertiary hill country of Blairs block adjacent to Mawhera forest, the soils have developed from consolidated, non-indurated muddy sandstone and siltstone, plus solifluction deposits and colluvium. With this exception and that of localised alluvial reworking, all soils date from periods of glacial deposition between 23 000 and 14 000 years ago, and are therefore comparatively young. Since the last phases of the Otira glaciation, the principal vegetation has been mor-forming podocarp-hardwood forest. Climate however, particularly the high rainfall (more than 2500 mm), has been the dominant factor determining soil characteristics, giving rise to a spectrum of soils which are gleyed and/or podzolised to various extents (Powell and Taylor, 1979).

The podzolisation and gleying processes are often difficult to separate (Mew and Leamy, 1977), but both podzolised and gleyed soils are generally acid to very acid and tend to have low to very low natural nutrient status, including trace element deficiencies. Poor drainage and high natural watertables are characteristic, caused by impedance of downward water movement by the iron pan and of lateral movement by the massive silty and cemented nature of the subsoil horizons. These factors, coupled with comparatively shallow, stony

profiles are characteristic of the "pakihi" soils dominant on the Farm Settlement, and cause severe difficulties for farming.

Recent soil surveys connected with plans to utilise West Coast beech forests have covered considerable areas of North Westland, including the Farm Settlement (Mew and Leamy, 1977). The mapping scale used was 1:63 360 or 1:50 000. On the Farm Settlement, the following soils were recognised: recent soils on the river flats; yellow-brown earths, gley soils and gley podzols on the terraces; yellow-brown earths and podzols on the morainic hill country; and steepland soils related to yellow-brown earths on the hill country underlain by Tertiary sediments (Mew, 1979). Their distribution is shown on Figures 7 and 8.

Most of Blairs block has been mapped as gley soils of the Maimai series, occurring on the poorly drained Loopline glacial outwash terrace. Soils on the small areas of alluvial terrace adjacent to the Arnold River include well drained recent soils of the Hokitika series, well drained yellow-brown earths of the Ikamatua series (on a slightly raised post-glacial terrace), and complexes of Hokitika soils and imperfectly drained, moderately gleyed recent soils of the Harihari series. On the degradational alluvial terraces in the north-west there is a complex of Harihari recent soils and very poorly drained Rotokohu organic soils. There is a variety of soils within the Loopline morainic hill country in the south-east of the block, including very poorly drained Kini organic soils, poorly drained Flagstaff gley soils, and complexes of imperfectly drained Moana podzols and well drained Hochstetter yellow-brown earths. The soils on the small areas of Tertiary hill country are mapped as Callaghans steepland soils.

On Weka and Ruru blocks there are distinctively different soil patterns on the moraines and outwash terraces. Both the Loopline-2 and Moana moraines are characterised by complexes of well drained Hochstetter yellow-brown earths and imperfectly drained Moana podzols. Additionally areas of Hochstetter yellow-brown earths and Flagstaff gley soils occur about and north of Lady Lake, and poorly drained Okarito gley podzols north of Kangaroo Lake. Maimai gley soils are dominant on the glacial outwash terraces. In the northern part of the two blocks they occur in complexes with poorly drained Kurara gley podzols or imperfectly drained Ahaura yellow-brown earths (mottled phases). Well drained recent soils of the Hokitika series are present on the

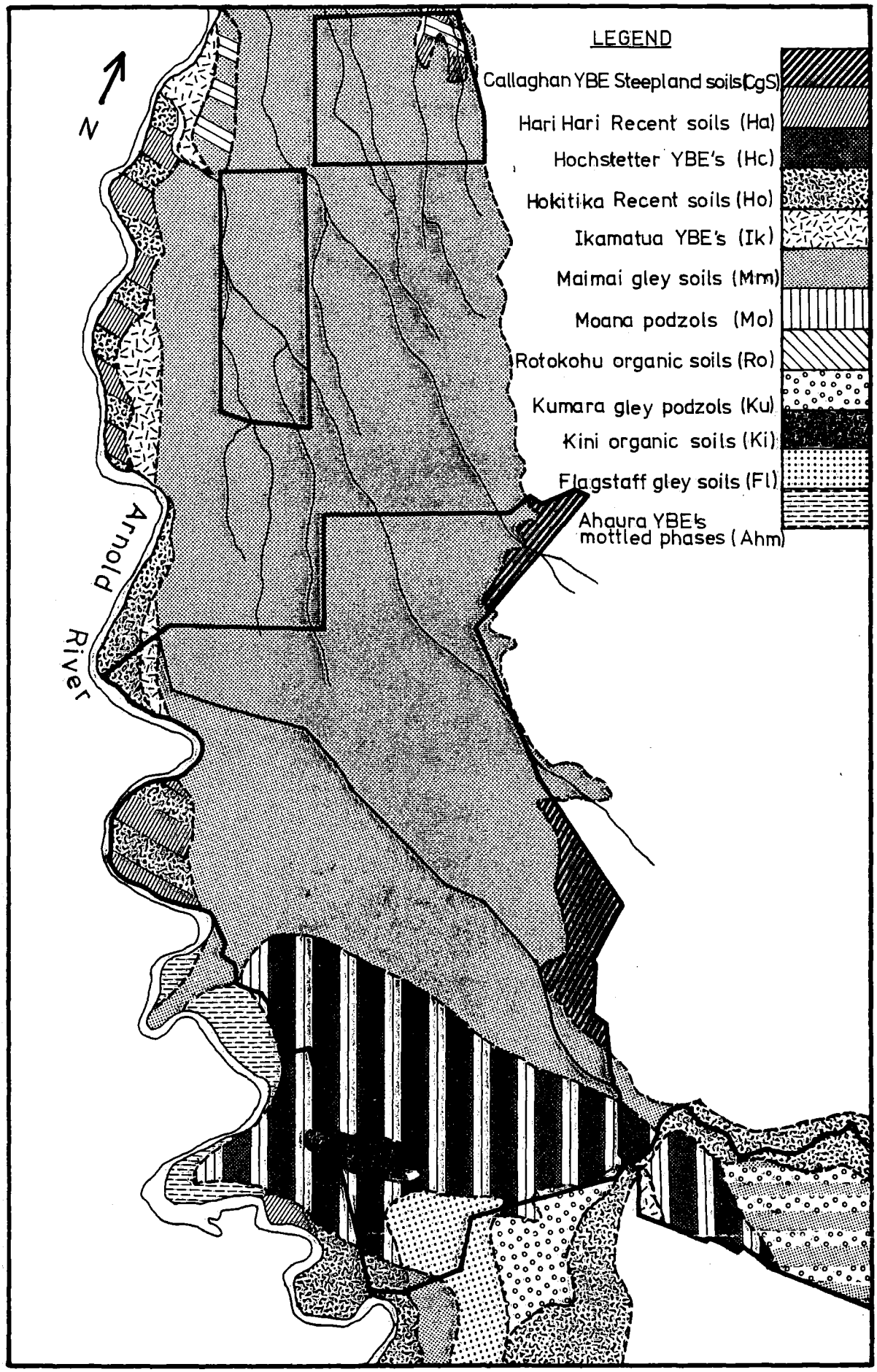

FIGURE 7: Pedological Map of Blairs Block (Scale 1:50 000). (Base Map from Mew, 1979.)

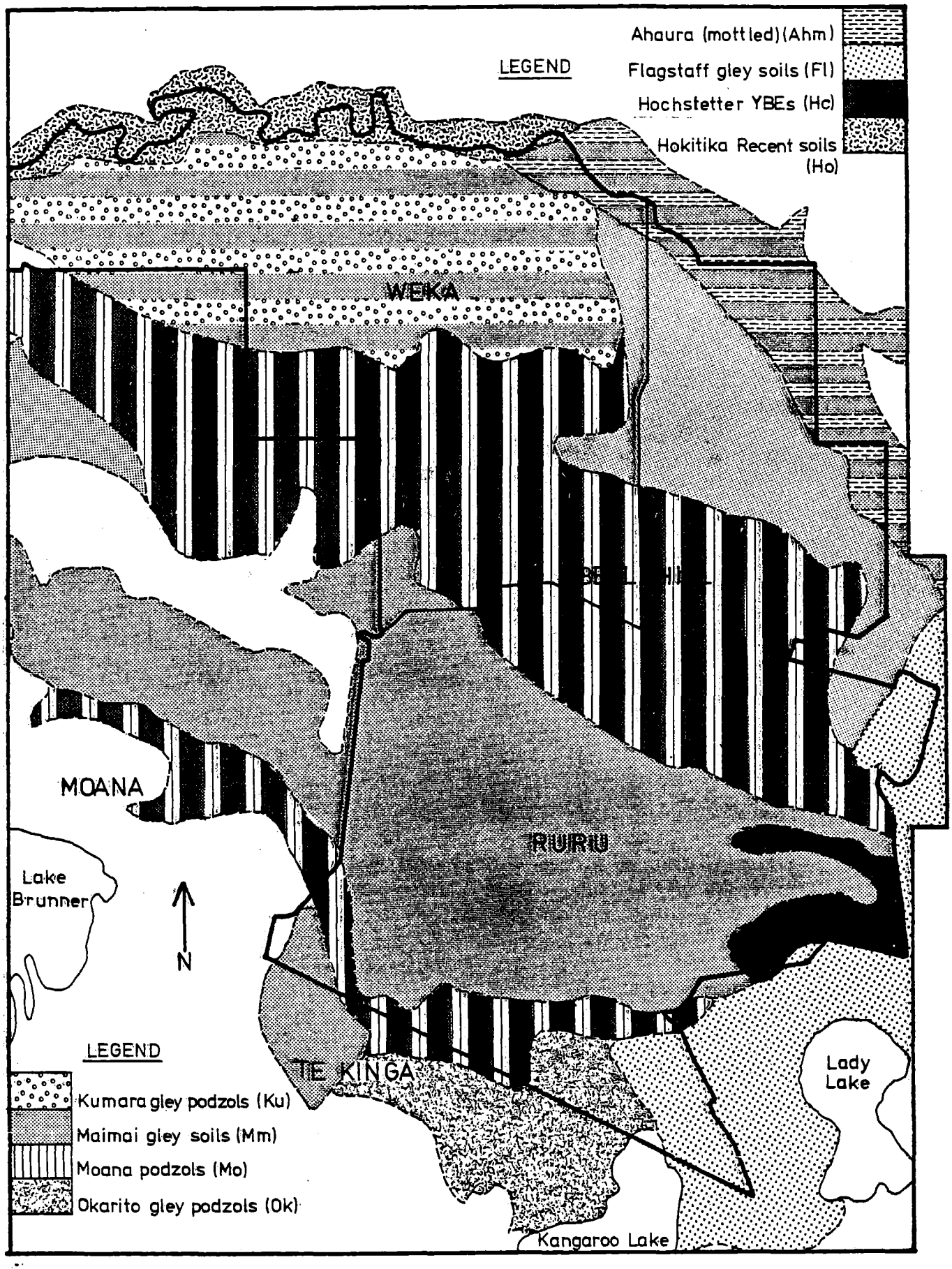

FIGURE 8: Pedological Map of Weka and Ruru Blocks (Scale 1:50 000). (Base Map from Mew, 1979.)

degradational alluvial terrace adjacent to Deep Creek.

Two other features of the soils of the Farm Settlement may be noted. Mew and Leamy (1977) found an increasing incidence of gleying on low glacial outwash terraces with increasing rainfall, and this trend would be expected on the Farm Settlement along the inland rainfall gradient. The trend probably also holds for other soil development processes, including podzolisation (cf. Tan, 1971 and Stevens, 1968a). Secondly, differences may be expected between the Maimai soils on the Loopline-2 and the younger Moana outwash terraces (Campbell, 1975), although no major differences were reported during the recent soil surveys (Mew, 1979).

2.5 VEGETATION

2.5.1 History of the Vegetation

The history of the vegetation in the Farm Settlement region prior to the Otira Glaciation is obscure, but pollen analysis of Otiran and Aranuian (or post-glacial) sediments shows the broad pattern of the more recent vegetation changes.

During the mid-Otiran, more than 18 000 years ago, a barren treeless landscape existed at Kamaka and Totara Flat in the Grey Valley, 25 km in front of the ice limits (Suggate and Moar, 1970). The vegetation there was dominated by sedges and grasses growing in swampy ground. Vegetation was probably even less developed around the present Farm Settlement on actively aggrading surfaces close to the ice limits.

Moar (1971), in a pollen study based partly on peat deposits from the Farm Settlement and Lady Lake, showed a successional sequence during the Aranuian from shrubland through dicotyledonous forest to podocarp forest. The earliest Aranuian vegetation was dominated by Gramineae, *Coprosma*, and *Myrsine* species. This was followed by a short period of forest dominated by kamahi (*Weinmannia racemosa*)[1] but including other dicotyledons and an element of rimu (*Dacrydium cupressinum*), kahikatea (*Podocarpus dacrydioides*) and other podocarps. Radio-carbon dating showed rimu forest beginning to spread about 9000 years ago, but

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1. Botanical nomenclature for indigenous species follows Brownsey (1977) for the *Asplenium* species, Philipson (1965) for the genera of the Araliaceae, and Allan (1961) for the remaining ferns and dicotyledons. Monocotyledons follow Moore and Edgar (1970), except for Arundinoideae which follow Zotov (1963) and remaining Gramineae which follow Cheeseman (1925). Adventive species follow Healy and Edgar (1980) for monocotyledons except gramineae, and Parham and Healy (1976) or common usage for all others.

the dicotyledonous element remained. A rise in red beech (*Nothofagus fusca*) type pollen shows the spread of beech species in the region over the last 2400 years.

The pattern of rimu dominance in the lowlands continued until the advent of European settlement, though it is likely that as soil development proceeded associated species requiring high fertility soils (such as kahikatea) tended to be replaced by less demanding species such as silver pine (*Dacrydium colensoi*), pink pine (*D. biforme*) and cedar (*Libocedrus bidwillii*). Though the forests were by no means static, there is no convincing proof of climatic and associated ecologically significant vegetation changes (Moar, 1971). Moa crop stones have been found in Mawhera forest immediately north of the Farm Settlement (Young, 1967), but the extent of moa browsing and its effects on vegetation are open to speculation (Greenwood and Atkinson, 1977).

2.5.2 Pre-European Vegetation

The vegetation of the Farm Settlement region prior to the advent of Europeans consisted almost exclusively of podocarp and podocarp-hardwood forest, plus small areas of beech forest and beech outliers. Forest remnants demonstrate wide variation in the former forests related to topography and associated geological, drainage and soil patterns.

2.5.2.1 Podocarp and Podocarp-Hardwood Forest. Podocarp and podocarp-hardwood forests formerly covered most of Blairs block and almost all of Ruru and Weka blocks.

Dense podocarp forests predominated on the glacial outwash terraces. The common canopy species were rimu, kahikatea, miro (*Podocarpus ferrugineus*), Halls totara (*P. hallii*)[1], silver pine, pink pine and cedar, and associated sub-canopy hardwood species included kamahi, quintinia (*Quintinia acutifolia*) and mountain toatoa[2] (*Phyllocladus alpinus*). Rimu was physiognomically and quantitatively

1. There is considerable hybridism within populations of true totara (*P. totara*) and *P. acutifolius* in Westland (Wardle, 1972). According to Wardle, true totara does not occur above about 150 m in the north-western part of the South Island. With the possible exception of alluvial terraces in the west of Blairs block, it is therefore unlikely to be present on the Farm Settlement. The narrow, pungent-leaved *P. acutifolius* was readily identified during this survey, but Halls totara and possible tall trees of the *P. totara-acutifolius* complex were not distinguished and all are referred to as Halls totara in this report.
2. Hereafter shortened to toatoa.

dominant, and tall dense to very dense stands of medium diameter trees covered most of the Farm Settlement terraces. Kahikatea, a species of fertile but wet or swampy sites, was of limited extent except where it occurred with rimu on partially swampy sites. On localised more poorly drained and podzolised sites there were lower, stunted forests composed of silver pine, pink pine, toatoa, cedar, manuka *(Leptospermum scoparium)* and sometimes small rimu, kamahi, and quintinia. Vegetation patterns were by no means simple however, and there were many intermediate associations forming complex mosaics.

Forest remnants show matai *(Podocarpus spicatus)* was common and sometimes dominant on the alluvial degradational terraces, especially on the tributaries of Molloys Creek on Ruru block. Kahikatea was usually dominant on such sites, and Halls totara and cedar were often found especially towards terrace edges. The kanuka *(L. ericoides)* that is now often present represents a seral community atypical of former forest communities on such sites. Along Deep Creek, matai and kahikatea commonly occurred in the red beech forest.

On the better drained morainic hill country in the centre of Ruru and Weka blocks, and on the Tertiary hill country of Blairs block, the forests were principally of the podocarp-hardwood type. They consisted of tall, large diameter rimu and, to a lesser extent, miro emergent above a canopy of kamahi, quintinia, toatoa and other hardwoods. Southern rata *(Metrosideros umbellata)* was also present on the Tertiary hill country. Podocarp trees, though physiognomically dominant, were considerably less dense than on the terraces.

2.5.2.2 Beech Forest and Beech Outliers. By the time of European settlement, the distribution of beech species in North Westland had extended to the Nelson Creek valley and up part of the Arnold valley, including lower parts of Blairs block (Fig. 9). To the south, apart from a number of outliers, there was a 300 km gap in beech distribution between the Arnold valley and the Paringa River.

Because of its very slow migration rates, the regional distribution of beech was probably not greatly different from that at the end of the Otira glaciation (June, 1980). During the last glacial phase there were numerous beech refugia north of the present boundary which subsequently expanded and coalesced following retreat of the ice. The slow rate of expansion and southward migration was probably due

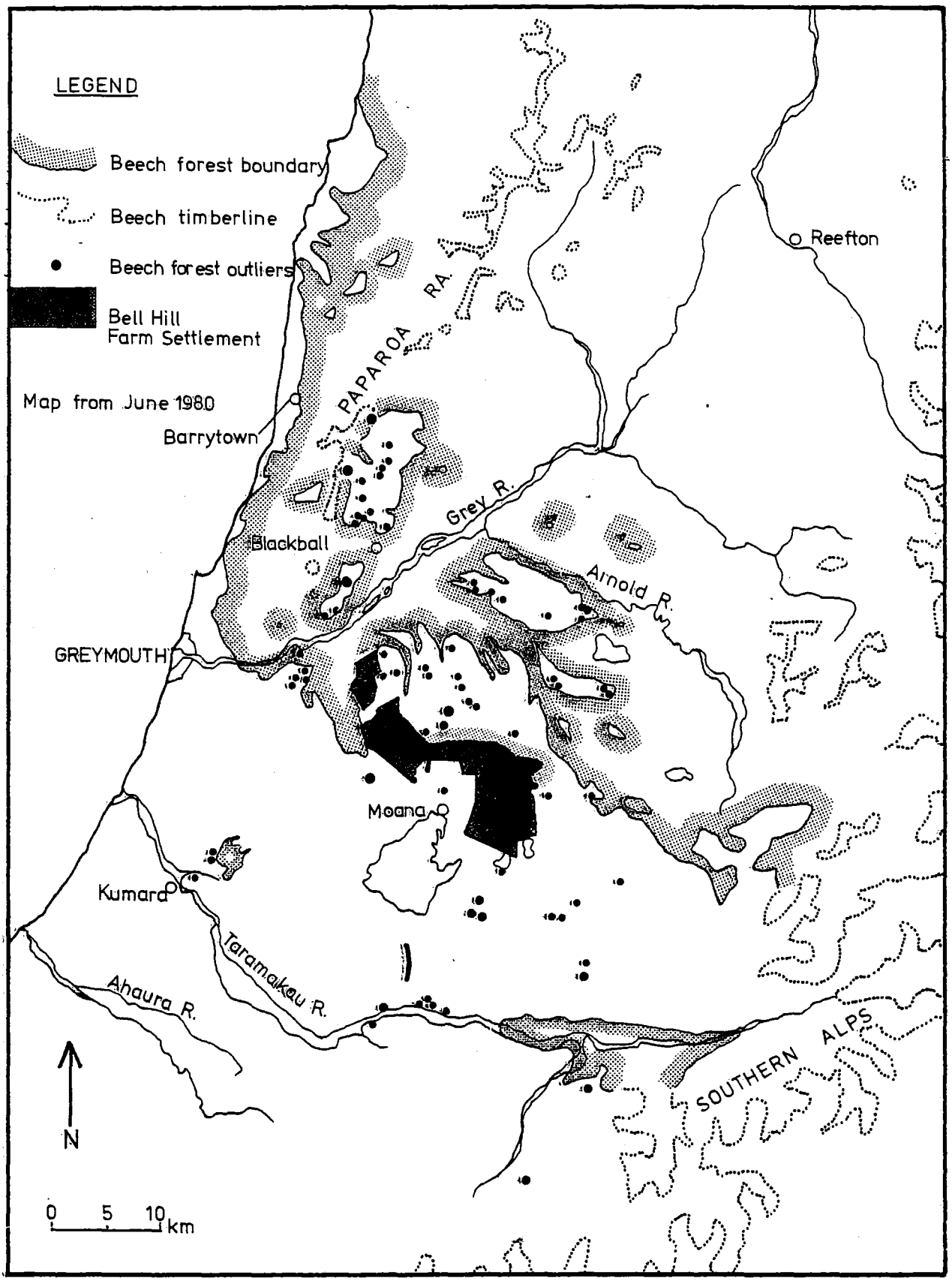

FIGURE 9: Map of Present Distribution of Beech Forest in North Westland (Scale 1:500 000). (Base Map from June, 1980.)

to competition from already established podocarp-hardwood forests, limited seed dispersal mechanisms, and specificity of site requirements by beech species.

Generally the pattern north of the present boundary is one of beech forest extending up the lower glacial terraces and alluvial flats of the river valleys, and podocarp-hardwood forest on the surrounding higher hill country. Red beech *(Nothofagus fusca)* and mountain beech *(N. solandri* var. *cliffiortioides)* are the two species occurring at the regional southern limit, though hard beech *(N. truncata)* and silver beech *(N. menziesii)* are not far to the north. Along the boundary in the Grey valley lowlands, red beech usually occurs on the younger, more fertile soils and mountain beech on the older glacial soils.

Precise boundaries between beech and podocarp forest are now difficult to define in many areas where there has been large scale forest clearance (including Blairs block). Forest remnants provide broad boundary definitions, which may be made more precise where the distinctive charred stumps of red beech are still present. Where no such evidence is available, perhaps only pedological characteristics remain to indicate the precise boundary (Campbell, 1975). There are several currently isolated beech stands on Blairs block which were probably once joined to the main beech stands on the Arnold River via "beech fingers" extending up small creeks.

Of the outliers south of the boundary, one is probably a relict which survived the last glacial period but the remainder appear to be the result of chance colonisations during the Aranuian period (June, 1980). They are widely scattered, from the Greenstone Valley (four species) to Mt Te Kinga and the Crooked River Valley. One of the largest is on the Farm Settlement along Deep Creek. It contains both red and mountain beech, and a small, previously unrecorded silver beech stand. Though disjunct, it is very close to the main beech area in the Nelson Creek and Haupiri valleys to the north, and is probably the result of post-glacial colonisation.

There are a number of small outliers on the Farm Settlement, some consisting of less than 10 trees. Red beech occurs in all of them, and mountain beech in some. It is possible that some small outliers on the Farm Settlement were obliterated during the forest

clearance period, but it is difficult to assess the likelihood of this. On the one hand, most of the smallest outliers (the most vulnerable) are adjacent to watercourses which suggests that outliers on such sites may have had better chances of survival from fires during the forest clearance period. On the other, riparian zones are the favoured sites of red beech, the most common species, and there is little reason to expect that it, at least, occurred elsewhere. Present beech outliers on the Farm Settlement are listed in Table 2.

There are several other beech outliers in the vicinity of the Farm Settlement. These include a previously unrecorded red beech tree on land adjoining r38 (S52: 074752), a red beech outlier of approximately 2-3 ha east of the Bell Hill scenic reserve (S52: 083743), and a very small red beech outlier in Otira-Kopara State forest near the south-east corner of Ruru block (S52: 051704). There is a further previously unrecorded stand beside the Arnold River near the south-east corner of Blairs block (S51: 950767). Records of all known beech outliers in the North Westland region as a whole are found in June (1980).

2.5.2.3 Other Vegetation. The extent of natural "pakihi"[1] vegetation on the Farm Settlement was very limited because of the relative youth of soils on the glacial outwash terraces. Morgan's (1911) geological map of the Greymouth region, which was compiled before the main forest clearance period and covered about one-half of the present Farm Settlement, shows swamp, which was possibly natural pakihi, occurring only in the south-west corner of Ruru block. This is on the north side of the Moana moraine wall, immediately west of the new Ruru road. Drainage appears to have been greatly impeded here but the area has now been drained and developed. Other natural pakihis outside the coverage of Morgan's map are unlikely. All present pakihi vegetation is therefore man-induced and, because the soils on which it occurs are not as gleyed and podzolised as those of natural pakihis,

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1. Maori word, meaning "open grass country, barren land".

TABLE 2: Present Beech Outliers on Bell Hill Farm Settlement

	Outlier (Name or Forest Remnant Number(s)[1])	Beech Species
1.	b7[2]	Red
2	b8	Red; red x mountain
3.	b8[3]	Red x mountain
4.	b19[4]	Red; mountain
5.	b20[4]	Red; mountain
6.	Deep Creek[5]	Red; mountain; silver
7.	w58	Red; mountain
8.	r54	Red
9.	r58	Red; mountain
10.	r97, r102, r103	Red; mountain

Notes:

1. Key to Forest Remnant Numbers: b = Blairs; w = Weka; r = Ruru.
2. Single pole only.
3. Single tree only.
4. Probably once joined to Arnold River beech stands (cf. notes in Forest Remnant Inventory Data, Appendix 7).
5. A large outlier consisting, on the Farm Settlement, of b22, w4, w12, w16, w17, w18, w19 (silver beech), w34, w37, r1, r2, r5, r7.

is a seral stage in the successional sequence back to tall forest.

A small partly infilled kettle-hole bog (Nan's Kettle) in Loopline morainic hill country on Weka block represented the only natural wetland on the Farm Settlement. There were also several infilled peat swamps on the same geological formation on Blairs and Ruru blocks. The natural vegetation on these has since been much modified by burning.

2.5.3 Vegetation Changes in European Period

Although there is evidence of forest fires in North Westland in the Maori period, there do not appear to have been any within the Farm Settlement area. The first significant European impact on the vegetation of the Farm Settlement region began in the 1860's during the early gold rushes. However although major rushes occurred at nearby places such as Notown, Red Jacks, Nelson Creek and Maori Gully, mining on and in the vicinity of the Farm Settlement appears to have been very limited. The only evidence is workings in the headwaters of Jones Creek east of the Bell Hill road, a number of tunnels in the hill country on Blairs block near Molloys Lookout and the headwaters of Candlelight Creek, and sluicing channels adjacent to Deep Creek above its gorge. Compared with subsequent forest milling, the gold miners' impact was minimal.

Forest milling began in the Grey Valley on a small scale in the 1860's but was initially limited by transport difficulties (Vaney, 1977). In the early 1890's the Midland Railway line was extended from Stillwater through the Arnold Valley to Jacksons, and from then on the timber industry began to boom along the valley. Next to mining, the timber industry was the most important economic activity in the Greymouth region at the beginning of this century (Morgan, 1911).

The history of logging in the area encompassed by the present Farm Settlement is somewhat obscure. In 1905 some of the largest sawmills in Westland were operating in Grey County, especially around Lake Brunner (Vaney, 1977). Morgan's (1911) geological map shows at least four mills logging the western part of the Farm Settlement at that time: Baxter's mill on the present abbatoir site at Kokiri, Marshall's silver pine mill on Weka block near Deep Creek, Jack's mill at Kotuku, and the Lake Brunner Sawmilling Company at Ruru. A number of other

mills are known to have existed in the vicinity, including ones at Kokiri, Kaimata, Aratika, Deep Creek, Moana, Ruru, Te Kinga and Bell Hill (town) (Vaney, 1977; Page, 1980). The mills were generally small by present standards, most cutting up to about 20 m^3 per day (Morgan, 1911). Little remains of these mostly 'fly-by-night' operations, with only the Ruru mill still operating. This was the largest mill in Grey County in the 1890's, and is presently logging in the Evans River Valley near Kopara.

Most logging was done using tramlines to provide access, and the steam hauler to extract logs from the bush. Many old tramlines, clearly visible on aerial photographs, cross the present Farm Settlement area. In the past tramlines have extended in several directions: from Baxter's Kokiri mill to Candlelight Creek; north from Stratford and Blairs' mill beside the Arnold River at Patara; from Ruru to near Lady Lake to Bell Hill (town); from Kotuku across the northern parts of Weka and Ruru blocks near Deep Creek; and from Kotuku east to the southern part of Weka block (Morgan, 1911). The only mill on the Farm Settlement appears to have been Marshall's silver pine mill (S52: 017793), the remains of which have recently been unearthed by drain digging.

Because of the high volumes and easy access, early milling concentrated on the dense podocarp stands on the low terraces and river flats. The chief timber tree was rimu. Others cut included silver pine, kahikatea, red beech and, to a lesser extent, totara, matai, miro, hinau *(Elaeocarpus dentatus)* and silver beech (Morgan, 1911). Logging practices were wasteful and much good timber was left behind. The forests to the east, including Ruru block, were logged slightly later, but by the late 1920's the Farm Settlement area was practically cutover. There is evidence that some forest remnants logged during the early logging period have been re-logged more recently for the podocarps originally left behind.

Subsequently much of the land was repeatedly burnt to clear it and encourage growth of pasture grasses. However such methods often failed and, as elsewhere in Westland, initiated a degradation process to induced pakihi. The development of pakihi is related to the swamping of the surface soil following forest removal. The forest is replaced by a vegetation consisting of manuka, ground ferns,

coarse grasses and rushes. Although pakihi lands were long regarded as unsuitable for agriculture or forestry, experimental development work was initiated by the Ministry of Agriculture and Fisheries, Lands and Survey Department, and Forest Service in the 1950's and 1960's. The Bell Hill Farm Settlement was one of the first such areas. By the use of modern technology, particularly aerial oversowing and top-dressing, most of its pakihi lands are now developed pasture.

2.5.4 Present Natural Vegetation of Bell Hill Farm Settlement

The majority of the Farm Settlement is now developed pasture.

There are small areas of swamps, ponds, rivers and streams, kettle-hole bog, and induced pakihi. These habitats have been much modified by European settlement activities, and in general natural vegetation remains only where they have been protected by water or surrounding forest (as in the case of stream banks and the kettle-hole bog) or where predominantly natural vegetation has recolonised (as in the case of induced pakihi). Some nevertheless retain considerable natural value.

The 1227 ha of forest remnants and shrublands are the predominant natural vegetation remaining on the Farm Settlement.

2.5.4.1 Peat Swamps and Wetlands. Nan's Kettle[1] (S52: 024762[2]) is a partly infilled kettle-hole lake within the Loopline morainic hill country on Weka block. A small tarn in the centre of the hollow is surrounded by large plants of *Carex secta* and *C. virgata*, and is drained by a stream in the south-east corner. The hollow is underlain by nearly five metres of peat. Charred stumps and logs are scattered over the peat surface, the remains of the former forest vegetation.

Maria's Mire[1] (S52: 038743[2]) is a swampy infilled lake within the Loopline moraine belt on Ruru block. There is an outlet in the north-west corner which drains into a tributary of Molloys Creek.

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1. Nan's Kettle and Maria's Mire are names taken from Moar (1971), and are not recognised by the New Zealand Geographic Board.
2. Moar's (1971) map references, based on provisional maps, are slightly in error.

The bog has been frequently burnt, and charred stumps of small trees are scattered throughout the present diverse swamp vegetation. It is underlain by more than five metres of peat and other pollen-containing sediments.

A third peat bog west of the woolshed on Ruru block (S52:047746) was probably also once forested, but now supports a swamp vegetation dominated by *Carex virgata*. There is not the same thickness of peat as in Nan's Kettle and Maria's Mire (Moar, 1980). Two drains, each more than one metre deep, have recently been dug through the peat.

Moar (1971) analysed vertical sections of the peat in Nan's Kettle and Maria's Mire as part of a major regional study of fossil pollen and post-glacial vegetation. The two peat swamps are thus important reference sites for scientific understanding of vegetation changes in North Westland since the Otira glaciation.

Apart from the tarn at Nan's Kettle, the only wetlands on the Farm Settlement are numerous small man-made ponds. As far as was ascertained, these lack significant natural vegetation but they do provide important habitat for waterfowl.

2.5.4.2 Induced Pakihis. Pakihi vegetation is characterised by surface water and an association of manuka, swamp umbrella fern (*Gleichenia circinata*), peat moss (*Sphagnum spp.*), rushes (*Juncus* spp.), gahnia (*Gahnia rigida*) and wire rush (*Calorophus minor*), with bracken (*Pteridium aquilinum* var. *esculentum*), ring fern (*Paesia scaberula*) and other ground ferns on drier mounds (Washbourn, 1972). Pakihi vegetation is a fairly common sight in North Westland. Almost all is man-induced, the result of forest clearance on poorly drained soils where a rising water table has inhibited forest regeneration.

Much of the vegetation on the Farm Settlement after the early forest burning period could no doubt have been loosely described as pakihi. However practically all has been converted to pasture in the course of the present farm development programme. The only significant occurrence of well-developed pakihi on the Farm Settlement is a 9.3 ha area in the north-east of Ruru block on the north side of Deep Creek (hereafter referred to as the "Deep Creek pakihi"). There are two other instances, in the far north-west of Blairs block (around forest remnants b5 and b6) and in the far north of Ruru block (north of the Deep Creek road). Both are small and have evidently been burnt or

otherwise modified comparatively recently. Only the Deep Creek pakihi was examined in detail.

That the Deep Creek pakihi is fire-induced is evident from the many dead standing tree trunks. The pakihi probably dates from the forest clearance in the early part of this century. It may well have been spared repeated subsequent burning because of its isolation. The only recent modification has been the new road constructed on its northern edge.

The pakihi vegetation is varied. Rushes and peat moss are dominant and there are pockets of manuka, *Coprosma* species and other shrubs. A total of 50 moss, fern and other plant species was recorded from the pakihi (listed in Appendix 1). Ground conditions are wet, a phenomenon evidently related to the gley soil overlying Loopline glacial outwash gravels. Regeneration by forest species is extremely sparse apart from marginal manuka shrublands at the edge of the surrounding forest.

The pakihi is notable for the presence of the moss *Sphagnum subnitens*. *S. subnitens* was previously known from only five lowland localities in New Zealand, four of these in North Westland (Dobson, 1975). The species is apparently rare in New Zealand, although it is widespread in the Northern Hemisphere. Whilst further collecting of mosses may reveal a wider distribution in Westland, there can be little doubt that conversion of the species' habitat to pasture and exotic forest will continue to reduce its range.

2.5.4.3 Forest Remnants and Shrublands

(a) Introduction

As previously described (section 2.5.2), patterns in the natural forest vegetation on the Farm Settlement are closely related to landforms. However in remaining forest areas, variations upon these patterns have been superimposed by two historical events, the regional migration of beech species, and human modification.

Where beech species are present, beech-podocarp assocations occur which are ecologically distinct from podocarp and podocarp-hardwood forests. Immediately before Europeans arrived, beech species (red and mountain) covered a comparatively small area within the present Farm Settlement boundaries. Beech on parts of Blairs block is contiguous with the main beech stands of North Westland, but all other beech stands are outliers.

Human modification has been of two basic kinds. The first is the disproportionate effect of logging and burning on the different types of forests. Generally forests on outwash terraces and rolling hill country are now under-represented in comparison with their original extent, and those on alluvial terraces and steep morainic slopes and gullies are over-represented. There are several likely reasons for this, apart from the obvious desirability of flat or rolling land for farming. Forests in moist gullies and on steep slopes were probably less accessible to early loggers, and may have been able to survive forest clearance fires. Forests alongside creeks and streams would likewise have fared better during fires, and there also appears to have been better subsequent regeneration on the higher fertility alluvial soils. Similarly, as beech species more often than not occurred on alluvial terraces and were not highly valued for their timber, beech areas are also over-represented.

The second kind of modification of the remnant forest vegetation is logging, burning and grazing. Nearly all forest remnants have been cutover for their podocarps. Most remaining tall podocarps are small, or of poor form, or were otherwise left behind because of some "defect". Subsequent podocarp pole regeneration is frequent.

The effects of burning have varied according to site. Dense regenerating podocarp (particularly kahikatea) or red beech pole stands occur on some of the more fertile alluvial areas and on some sites where ground disturbance has favoured these species. Elsewhere regeneration following burning has been limited to areas of low hardwoods and shrublands. Such shrublands represent early seral stages in a more prolonged succession to high forest. They may exist independently but most are found around or adjacent to forest remnants. Many have since been cleared for pasture development.

A long history of grazing by cattle and other introduced animals has changed the understorey of most remnants, to the extent that in some there are now very few seedlings and saplings and the forest floor is bare except for weeds and disturbed organic soil. Grazing has had its most profound effects in the longest developed areas of the Farm Settlement.

Further, more subtle, forms of modification are caused by over-sowing, top-dressing and artificial drainage. Oversowing and top-dressing effects are confined to small remnants and the edges of larger

ones. Changes in vegetation composition related to increases in soil chemical fertility following fertiliser application are long-term and difficult to gauge; certainly it is a field worth some research in New Zealand. The introduction of weeds through oversowing is generally confined to areas without a full canopy, where there is sufficient light for plant establishment on the forest floor. Changes in soil moisture conditions consequent upon drainage of the outwash terraces are likely to cause shifts in vegetation composition towards species usually occurring on comparatively better drained sites. Through-drains have damaged the physical integrity of many forest remnants. They also facilitate the entry of weeds, and in some instances have caused ponding and local vegetation die-off.

The assignment of all remaining forest vegetation on the Farm Settlement to individual "forest remnants" has been somewhat arbitrary. Most forest remnants are recognized as independent and isolated. Two exceptions exist. Firstly, where small areas of similar vegetation occur close together, they have been clumped into one unit. Secondly, some large "forest remnants" have been subdivided on the basis of management boundaries such as fences, roads or tracks.

Each forest remnant is identified by a unique alphanumeric symbol. The letter denotes the block (b = Blairs, w=Weka, r=Ruru), the number the individual remnant within the block. The symbol is used throughout this text.

In total there are 204 forest remnants on the Farm Settlement. Generally they are small in size. Eighty-seven (43.1 percent) are each less than one hectare, and only 22 are larger than 20 ha. The largest is 74.0 ha. The combined area of the 22 largest remnants (869 ha) accounts for nearly three-quarters (73.0 percent) of the total area of forest remnant vegetation on the Farm Settlement. The distribution of forest remnant sizes is illustrated in Figure 10.

(b) Description and Mapping of Forest Remnant Vegetation.

For each remnant the following vegetation characteristics have been described: size of stand; landform; community classification, and major emergent, canopy and subcanopy species; and extent of modification. The descriptions are summarised in Appendix 7.

Where there is more than one community in a forest remnant separate canopy species lists are provided for each community. Up to 10 species

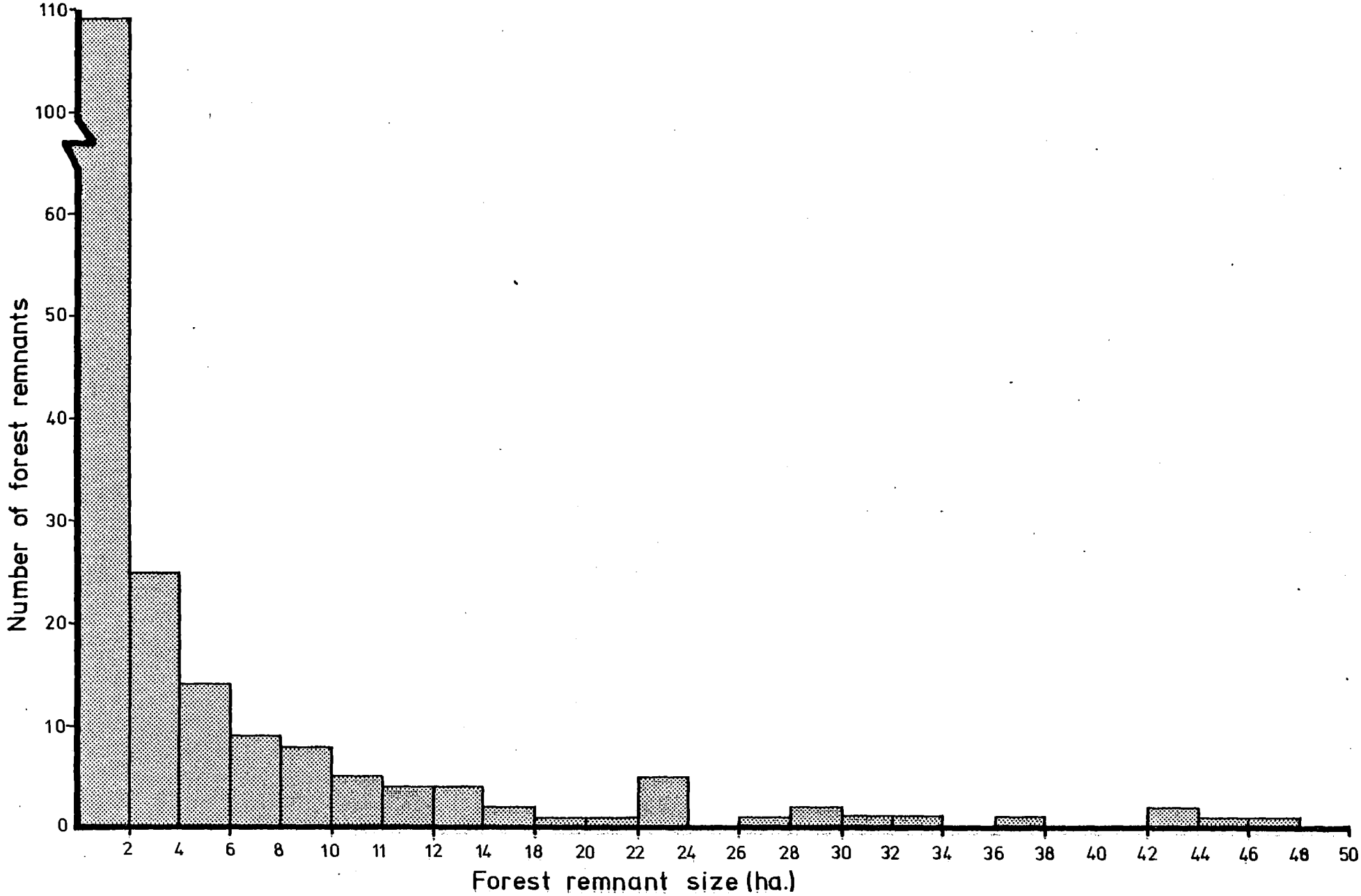

FIGURE 10: Graph of Forest Remnant Sizes on Bell Hill Farm Settlement. (Six Remnants Larger than 50 ha not shown.)

may be listed in a vegetation layer for a community which is of high diversity or has some spatial variation among its parts. However, lists of 2-6 species per vegetation layer are more common. In all cases species are listed in approximate decreasing order of abundance.

The vegetation maps (Figs. 14, 15 and 16) are based on the 1: 10 000 topographical maps of Farm blocks, and show the community or communities present in each forest remnant. Where there is more than one community per remnant, the boundaries are drawn on the basis of field inspection and/or stereoscopic aerial photograph interpretation. Boundary definition where there is much variation within or gradation between communities has had to be somewhat arbitary. Some shrubland communities not shown on the topographical base maps have been added to the vegetation maps using aerial photographs.

(c) Definition of Forest Communities.

The methods used here to define and describe the forest communities of the Farm Settlement are based on those in Park and Bartle (1978) and Park and Walls (1978). The communities are based on field descriptions, which include estimates of the cover of prominent species in the emergent and canopy, or canopy and subcanopy layers, and short species lists. The tree associations in the canopy and subcanopy have been chosen as the basis for forest community definitions because of their fundamental role in the structure and function of the rest of the community.

The primary criterion of community definition is landform. This criterion is used because of the considerable differencesin canopy structure and composition on different landforms, and the similarity in patterns within landforms. Within landform categories, there is secondary delineation and classification of communities according to the presence or absence of beech species and the effects of human modification. Secondary sorting is less quantitative and more subjective, the aim being to define broad vegetation units that are easily recognisable by people with only a limited familiarity of the native flora in preference to compiling numerous highly specific units. Consequently the communities may encompass a wide range of variation and may include minor specialised communities such as stream banks and moist fern gullies.

The fire-induced shrublands of the Farm Settlement reflect the imprint of human factors rather than natural features. They are therefore defined separately, on the basis of the extent of regeneration of podocarp and/or hardwood species.

It should be noted that some areas within broad land systems (as defined in section 2.3) have landforms and associated vegetation approximating those found in other land systems. For example, well-drained dissected areas on glacial outwash terraces have forest associations similar to those on morainic hill country. Likewise small terraces within morainic hill country have vegetation similar to that on glacial outwash terraces. The landforms and vegetation of such areas are identified by the local characteristics of the site.

(d) The Communities

The forest and shrubland communities on the Farm Settlement are summarised in Table 3.

In the community definitions which follow, all prominent emergent and canopy or canopy and subcanopy species are listed, in approximate order of decreasing abundance. There are also brief notes on the understorey and ground layers, landform, the condition or degree of modification of the community, and any particular local or regional biogeographical significance.

The virgin or least modified forest communities are classified and described with the corresponding cutover community. Most cutover forests retain some semblance of their original character. Given protection they will regain an approximation of that character by way of successional processes. Hence in the long-term the virgin and cutover forests will become indistinguishable. Virgin communities are distinguished by a lower case v suffix in their symbol.

Species lists for each community (in Appendix 2) are arranged in five broad categories: trees and tall shrubs; other shrubs, lianes and scramblers; ground cover and epiphytes; and ferns and fern allies. The lists are not exhaustive but rather are indicative of the species that are found in each community. Not all species listed will be found in any one locality, because of the variation within communities and the inclusion of specialised communities. There may be differences between species lists of virgin and modified communities but these are not separately recorded here. Modified forest communities are

likely to have more seral and weed species and, in some instances, reduced numbers of virgin forest species.

Also included with each species list in Appendix 2 is a listing of all forest remnants containing the particular community.

TABLE 3: Synopsis of Forest and Shrubland Communities on Bell Hill Farm Settlement

A. ON ALLUVIAL (OR COLLUVIAL) SOILS

- A1. Matai dominant, plus hardwoods and other podocarps.
- A2. Kahikatea and matai co-dominant, plus cedar, other podocarps, and hardwoods.
- A3. Kahikatea dominant, plus other podocarps, cedar, and hardwoods.
- A4. Rimu and kahikatea co-dominant, plus other podocarps, cedar, and hardwoods.
- A5. Red beech dominant, plus podocarps, cedar and hardwoods.

B. ON GLACIAL OUTWASH TERRACE SOILS

- B1v. Rimu and kahikatea co-dominant, plus cedar, miro, and hardwoods.
- B1. Kahikatea and rimu, plus other podocarps, cedar, and hardwoods.
- B2v. Rimu dominant, plus other podocarps, cedar, and hardwoods.
- B2. Rimu, plus other podocarps, cedar, and hardwoods.
- B3. Kahikatea and rimu emergent above cedar, toatoa, pink pine, manuka and kamahi canopy.
- B4. Cedar, pink pine, toatoa and manuka.
- B5. Mountain beech dominant, plus podocarps and other hardwoods.
- B6. Red beech dominant, plus mountain beech, podocarps, and other hardwoods.
- B7. Silver beech

C. ON GLACIAL MORAINIC HILL COUNTRY SOILS

C1v. Rimu and miro emergent above kamahi, quintinia and toatoa canopy.

C1. Rimu and miro emergent above kamahi, quintinia, secondary rimu, toatoa, broadleaf and marbleleaf canopy.

C2. Secondary kahikatea dominant, plus other podocarps and hardwoods.

D. ON TERTIARY HILL COUNTRY SOILS

D1v. Rimu and miro emergent above canopy of kamahi, quintinia, pokaka, southern rata and other hardwoods.

D1. Rimu and miro emergent above canopy of kamahi, quintinia, pokaka, marbleleaf, southern rata and other hardwoods.

E. INDUCED ASSOCIATIONS

E1. Shrublands with significant hardwood and/or podocarp regeneration.

E2. Shrublands without significant hardwood or podocarp regeneration.

Notes:

1. Virgin or least modified communities are denoted by a lower case v suffix.

2. The communities here listed alphanumerically are shown on the vegetation maps (Figs. 14, 15 and 16).

A. FORESTS ON ALLUVIAL (OR COLLUVIAL) SOILS

A1. Matai dominant, plus hardwoods and other podocarps

Scattered to medium density, bushy matai, mostly of large diameter but poor form; and sometimes kahikatea. Canopy or subcanopy species include toatoa, kanuka, cedar, broadleaf *(Griselinia littoralis)* and secondary kahikatea, plus less frequent Halls totara, silver pine, kamahi, marbleleaf *(Carpodetus serratus)*, manuka and pink pine.

The understorey and ground layers consists of ferns, mosses, small shrubs and seedlings, and are dense in most instances. Matai seedlings are often plentiful.

The community occurs only on Ruru block, on the narrow degradational alluvial terraces incised by Molloys Creek tributaries into the Moana outwash terrace. It has been logged throughout, but heavily only in one instance (r105). The presence of cedar, silver pine, Halls totara and pink pine, species characteristic of podzolised soils, suggests alluvium deposited on the glacial outwash terrace gravels is very thin.

A2. Kahikatea and matai co-dominant, plus cedar, other podocarps, and hardwoods

Scattered to medium density kahikatea and matai, plus cedar, Halls totara and, less frequently, rimu, miro and (adjacent to Deep Creek) red beech. Where the canopy is relatively intact (as in w37), the subcanopy layer is sparse. Elsewhere toatoa, secondary kahikatea, kanuka, broadleaf, kamahi and marbleleaf become more important with increasing intensity of past logging.

Understorey and ground layer ferns, mosses, shrubs and seedlings vary according to the extent of grazing and the density of higher vegetation layers.

This community occurs on the narrow degradational alluvial terraces on the Loopline and Moana outwash terraces. With two exceptions (w37 and b28), what remains has been heavily logged. Secondary kahikatea is common and is likely to form the future canopy.

A3. Kahikatea dominant, plus other podocarps, cedar, and hardwoods

Scattered to medium density kahikatea, and occasional matai, cedar, miro and rimu; emergent above a canopy ranging from pure dense kahikatea regeneration to quantitatively dominant secondary kahikatea plus toatoa, kanuka, kamahi and less frequent pink pine, broadleaf, manuka, and (adjacent to Deep Creek) secondary red beech.

The understorey and ground layers contain ferns, mosses, shrubs and seedlings where there is sufficient light available and stock grazing is limited. They are bare under dense, regenerating kahikatea canopies.

This community occurs on narrow degradational alluvial terraces on the Loopline outwash terrace, on an aggrading alluvial fan, and on the Arnold River alluvial terrace. All instances have been heavily logged, but they now contain dense stands of regenerating sapling and pole kahikatea, the future dominant canopy species. Seral species such as kanuka and manuka are likely to become insignificant as succession proceeds.

A4. Rimu and kahikatea co-dominant, plus other podocarps, cedar, and hardwoods

Scattered to medium density rimu and kahikatea, plus less frequent cedar, miro, matai, Halls totara, and (adjacent to Deep Creek) red and mountain beech; emergent above a canopy or subcanopy of secondary kahikatea, toatoa, kamahi, marbleleaf, manuka and less frequent kanuka and secondary rimu.

Understorey and ground layer ferns, mosses, herbs, weeds, shrubs and seedlings vary according to the extent of grazing and the density of higher vegetation layers.

This community occurs on narrow degradational alluvial terraces but is infrequent. What remains has been logged, often heavily, but there is ample advance growth of secondary kahikatea and rimu, kamahi, toatoa and other hardwoods to restore a full canopy.

A5. Red beech dominant, plus podocarps, cedar, and hardwoods

Canopy of tall, medium and large diameter red beech, usually with varying admixtures of kahikatea, rimu, miro, matai, cedar, Halls totara, mountain beech and red beech-mountain beech hybrids. The subcanopy is sparse and usually consists of young red beech, toatoa, marbleleaf, broadleaf, kamahi, wineberry *(Aristotelia serrata)* and pokaka *(Elaeocarpus hookerianus)*. In some instances the red beech forest has been heavily logged (for tramway construction) and/or burnt. Here a few tall red beech trees may remain emergent above a dense sapling and pole red beech canopy, sometimes with secondary kahikatea, kamahi and toatoa.

The understorey and ground layers are usually sparse, predominantly litter, but ferns, mosses, shrubs and seedlings are prominent in some places.

This community occurs on the narrow degradational alluvial terraces, principally along Deep Creek. What remains represents a large proportion of the former extent of such forest. Most has been only slightly modified, by logging of podocarps and stock grazing. A small area of similar forest occurs on steep slopes in the head of a creek in b30.

The principal value of the red beech communities on the Farm Settlement derives from their position on the beech-podocarp ecotone. The stands in the west of Blairs block are contiguous with the main North Westland beech stands, but all other occurrences are beech outliers or parts of beech outliers. Four outliers (b7, b8, r54, r58) were previously unrecorded.

B. FORESTS ON GLACIAL OUTWASH TERRACE SOILS

B1v. Rimu and kahikatea co-dominant, plus cedar, miro, and hardwoods

Dense stands of tall, varying diameter rimu and kahikatea, plus less frequent cedar and miro; the subcanopy, of kamahi, toatoa and broadleaf, is sparse.

The understorey and ground layers are sparse, on account of dense higher vegetation layers and grazing.

B1. Kahikatea and rimu, plus other podocarps, cedar, and hardwoods

Tall kahikatea and rimu in varying proportions, plus less frequent miro, cedar, Halls totara and matai, with overall scattered to medium density depending on intensity of past logging. Where the canopy is relatively intact, the subcanopy layer is sparse. Elsewhere secondary kahikatea, toatoa, kamahi, secondary rimu, broadleaf, manuka and less frequent marbleleaf, quintinia, silver pine and pink pine may form a lower canopy. Kahikatea regeneration is dense where the former canopy has been largely removed.

Understorey and ground layer ferns, mosses, shrubs and seedlings vary according to the extent of grazing and the density of higher vegetation layers.

These communities occur on the Moana and Loopline glacial outwash terraces. Most examples have been logged, and the original canopy has been eliminated from some.

B2v. Rimu dominant, plus other podocarps, cedar and hardwoods

Medium to high density stands of tall, varying diameter rimu, plus less frequent miro, cedar and kahikatea; the subcanopy, of kamahi, quintinia, toatoa, and less frequent broadleaf, pink pine and silver pine, is sparse.

The understorey and ground layers vary, particularly according to accessibility to stock. Some stands (w32, w41, r2, r15) are in very good condition and have a wide range of mosses, herbs, ground and tree ferns, shrubs and seedlings.

B2. Rimu, plus other podocarps, cedar, and hardwoods

Tall rimu, plus less frequent kahikatea, miro and cedar, of scattered to medium density depending on intensity of past logging. Where the canopy is relatively intact, the subcanopy is sparse. Elsewhere kamahi, toatoa, quintinia, secondary kahikatea, secondary rimu and less frequent broadleaf, pink pine and silver pine become more abundant with increasing intensity of past logging. Several stands of dense, lightly logged, pole and small tree rimu are included.

Understorey and ground layer ferns, mosses, shrubs and seedlings vary according to the extent of grazing and the density of higher vegetation layers.

These communities occur on the Moana and Loopline glacial outwash terraces, and on small terraces within the Loopline morainic hill country. Logging has practically eliminated the former canopy in some instances, but fortunately some excellent relatively unmodified examples have survived.

The recently gazetted Deadman ecological area at Glasgow Creek in Mawhera State Forest contains about 160 hectares of moderately dense rimu forest, being the only such remnant in State forest on the plateau between Nelson Creek and the Arnold River. However the Deadman ecological area occurs on very old glacial outwash gravels mapped by Nathan (1978) as pre-Waimungan, and ecologically it is quite distinct from that on the Farm Settlement. The density of rimu is much lower, and there is a well developed subcanopy layer of kamahi, quintinia, southern rata, toro *(Myrsine salicina)* and other hardwoods.

B3. Kahikatea and rimu emergent above cedar, toatoa, pink pine, manuka and kamahi canopy

Scattered tall kahikatea, rimu and smaller cedar, emergent above a canopy of toatoa, pink pine, manuka, kamahi and less frequent silver pine, secondary kahikatea, secondary rimu and Halls totara.

Understorey and ground layer ferns, mosses, shrubs, seedlings, weeds and litter vary according to accessibility to stock and the density of higher vegetation layers.

This community is characterised by the presence of tall kahikatea and rimu, and an understorey of cedar, pink pine, toatoa and manuka. It represents the vegetation of an intermediate phase in podzolisation and other soil development processes on the Loopline outwash terrace towards the highly podzolised soils of the B4 community. All examples have been logged, most notably for their silver pine content.

B4. Cedar, pink pine, toatoa and manuka

Cedar, sometimes emergent, or within a canopy of pink pine, toatoa and manuka, together with less frequent silver pine, secondary kahikatea, secondary rimu, broadleaf and (where beech is nearby) mountain and red beech.

Understorey and ground layer ferns, mosses, shrubs, seedlings, litter and weeds vary according to accessibility to stock and the density of higher vegetation layers. The undergrowth is dense where the canopy is relatively open.

This community is distinguished from B3 by the absence of tall emergent podocarps. It occurs on more podzolised sites, sometimes depressions, on the Loopline outwash terrace. It is possible that some forest areas which have been classified within the B4 community may belong to B3 except that all tall podocarps have been removed. Clarification of this would require pedological investigation. All present examples have been logged, at least for their silver pine content.

B5. Mountain beech dominant, plus podocarps and other hardwoods

A highly variable community, ranging from dense, almost pure mountain beech stands to stands with mountain beech as the most prominent element but including a wide variety of other species, such as red beech, manuka, toatoa, cedar, rimu, kamahi, pink pine, secondary rimu and/or secondary kahikatea. Some dense stands of pure regenerating mountain beech are included.

Understorey and ground layer ferns, mosses, shrubs and seedlings are usually sparse. Litter is often predominant, particularly under a dense canopy.

This community occurs on the Moana and Loopline outwash terrace gravels. Undoubtedly most examples have been logged for their podocarp element. Some exhibit dense pole regeneration following burning.

The principal value of the mountain beech areas on the Farm Settlement derives from their position on the beech-podocarp ecotone. The stands in the west of Blairs block are contiguous with the main North Westland beech stands but all other occurrences of mountain beech are as parts of beech outliers.

B6. Red beech dominant, plus mountain beech, podocarps, and other hardwoods

Tall, medium or large diameter red beech, usually with mountain beech, plus less frequent Halls totara, kahikatea, rimu, red beech-mountain beech hybrids and cedar. The sparse subcanopy consists predominantly of toatoa, kamahi and less frequent young red beech and mountain beech. Several dense stands of fire-induced secondary red beech are included.

Understorey and ground layer ferns, mosses, shrubs and seedlings are usually sparse. Litter is often predominant, particularly where grazing is intensive.

This community usually occurs on the Loopline glacial outwash terrace gravels. For convenience, one beech outlier (comprising r97, part r102 and part r103) on rolling Moana morainic hill country has been included. What remains has almost certainly been logged for its podocarp element but, except where burning has occurred, the canopy appears relatively intact.

The red beech dominant communities on young glacial outwash terraces on the Farm Settlement have significance in terms of their position on the beech-podocarp ecotone in North Westland. Remnants b19 and b20 were probably formerly contiguous to the main North Westland beech stands, but the remainder are outliers. Three remnants (r97, part r102 and part r103) north of Lady Lake, are the remains of one red and mountain beech outlier of more than 20 hectares. w58 is a previously unrecorded outlier.

B7. Silver beech

Small silver beech and a few red and mountain beech trees forming a dense canopy, plus numerous poles, saplings and seedlings. The forest floor is mainly litter, and there is a limited range of other species present.

On the Farm Settlement this community is represented only by one very small stand (less than 0.1 ha). It is located near Deep Creek (S52:020797) on a slope between the Loopline outwash terrace and an intermediate degradational alluvial terrace, adjacent to and immediately above an old tramline.

The trees appear to be all young. The largest is about 40 cm dbh[1], the remainder less than 30 cm. Seedlings and saplings are common within and up to 20 m outside the main stand, indicating that the silver beech is expanding into the surrounding modified red and mountain beech vegetation.

This silver beech stand has considerable natural and scientific value. In North Westland the main silver beech stands extend from the north only to the mid-Grey Valley, the Paparoa Range and the Upper Ahaura Valley (June, 1980). In the Grey Valley they lag up to 20 km or more behind the southward migrating red and mountain beech stands (Fig. 9). The silver beech on the Farm Settlement is one of about six small outliers which extend up to about 30 km south of the main silver beech stands. With the exception of the Greenstone Valley occurrence near Kumara, all appear to be chance establishments of the Aranuian period. Their existence points to fundamental questions on the dispersal mechanisms and post-glacial spread of the beech species in North Westland.

C. FORESTS ON GLACIAL MORAINIC HILL COUNTRY

C1v. Rimu and miro emergent above kamahi, quintinia and toatoa canopy

Tall, medium density, medium to large diameter rimu, miro and less frequent kahikatea, emergent above a canopy of kamahi, quintinia, toatoa and less frequent hinau, broadleaf and marbleleaf.

Grazing in both instances is limited by inaccessibility to stock, and understorey and ground layer ferns, mosses, shrubs and seedlings are abundant.

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1. dbh = diameter at breast height.

C1. Rimu and miro emergent above kamahi, quintinia, secondary rimu, toatoa, broadleaf and marbleleaf canopy

Tall, varying but usually low density rimu and miro, plus less frequent kahikatea and infrequent Halls totara; emergent above a canopy often of dense secondary pole stands, consisting of kamahi, quintinia, secondary rimu, toatoa, broadleaf, marlbeleaf, and less frequent secondary kahikatea, wineberry, toro, fuchsia *(Fuchsia excorticata)*, secondary miro and pokaka. Although rimu is nearly always more abundant than miro in virgin forest, the relative proportion after logging is highly variable. In some instances, all tall podocarps have been removed. Southern rata is present in a few locations.

Understorey and ground layer ferns, mosses, shrubs and seedlings are abundant where there is protection from grazing. Most examples however have been grazed, to the extent that in some areas only weeds and churned-up organic soil remain.

These communities are predominant on the Loopline and Moana morainic hill country, but similar communities on hilly slopes on the outwash terraces have also been included. There is considerable variation within the vegetation, partly related to differences in slope, aspect and time lapse since logging.

The C1 and C1v communities constitute the greatest proportion of the remaining forest vegetation on the Farm Settlement.

C2. Secondary kahikatea dominant, plus hardwoods and other podocarps

Sometimes scattered tall emergent podocarps, principally kahikatea; a dense regenerating canopy, of height varying according to time lapse since modification, ranging in composition from pure kahikatea to kahikatea dominant but including a wide range of other species, such as kamahi, toatoa, secondary rimu, broadleaf, silver pine and others.

The understorey and ground layers are sparse, principally because of the density of higher vegetation layers and the often intensive grazing.

This community usually occurs on the Loopline and Moana morainic hill country, on poorly draining slopes receiving surface and sub-surface drainage waters from adjacent higher land. Adjacent non-forest areas are often wet underfoot, but within the forest itself high transpiration rates appear to greatly reduce soil moisture levels.

This community probably represents a seral stage in the succession back to podocarp-hardwood hill country forest.

D. FORESTS ON TERTIARY HILL COUNTRY

D1v. Rimu and miro emergent above canopy of kamahi, quintinia, pokaka, southern rata and other hardwoods

Medium density tall medium-to-large diameter rimu, miro and infrequent kahikatea, emergent above a fairly dense canopy of kamahi, quintinia, pokaka, southern rata and less frequent toro, marbleleaf, hinau, Halls totara, toatoa, wineberry and fuchsia.

The understorey and ground layers consist of seedlings, shrubs, ferns, mosses and litter. All areas are fenced off from stock, and are only lightly grazed by wild animals (goat, red deer, possum).

D1. Rimu and miro emergent above canopy of kamahi, quintinia, pokaka marbleleaf, southern rata and other hardwoods

Scattered tall medium diameter rimu, miro and infrequent kahikatea, emergent usually above secondary pole stands of kamahi, quintinia, pokaka, marbleleaf and southern rata, plus less frequent wineberry, toro, fuchsia, hinau, and Halls totara. Often there is frequent rimu and kahikatea sapling and pole regeneration, and stands of wheki tree ferns *(Dicksonia squarrosa)* on burnt margins.

Where the canopy is dense, the understorey and ground layers consist predominantly of litter. Seedlings, shrubs, ferns and mosses become more common under relatively more open canopies. Grazing (by wild animals) is light, except for b18 which is accessible to stock and has been heavily grazed.

These communities occur only on Blairs block, on ridge tops and slopes on the southern edge of the late Tertiary sandstone and siltstone formations extending from the adjacent Mawhera forest. Only b18 and b22 are within the stocked area of the Farm Settlement. The virgin variant predominates on the upper slopes and ridges, the logged variant in valleys and on the lower slopes.

E. INDUCED ASSOCIATIONS

E1. Shrublands with significant hardwood and/or podocarp regeneration

A composite community, varying very much according to landform and soil conditions. Usually there is a mixture of successional shrub species, particularly manuka, kanuka and *Coprosma* spp., and young forest shrubs and trees of less than 3-5 m height. Other species present may include toatoa, secondary kahikatea, kamahi, pink pine, secondary rimu, wineberry, cedar, broadleaf, quintinia and silver pine.

This community is a fire-induced association, a consequence of forest clearance by burning. It encompasses shrublands in the early and middle stages of the successional sequence back to tall forest. The succession proceeds through the pioneer shrubs acting as a "nurse crop" and providing suitable conditions under which tall forest species can become established.

Most examples occur on the Moana and Loopline glacial outwash terraces, but they are also found on degradational alluvial terraces and on morainic hill country. Most are contiguous to forest remnants, and will return to similar forest provided there is no further major modification.

Similar communities occur on the periphery of many forest remnants, but are too small or narrow to map. In all cases they may be regarded as an integral part of the forest remnant because of the high probability of a return to tall forest.

E2. Shrublands without significant hardwood or podocarp regeneration

A community of shrub species, within which regeneration of forest species is limited to non-existent. Manuka is usually dominant to predominant. It is often accompanied by *Coprosma* spp. and gorse *(Ulex europaeus)* and less frequent secondary toatoa and kahikatea. The range and numbers of other species are limited.

The community is a fire-induced association, a consequence of forest clearance by burning. Most examples occur on the Moana and Loopline outwash terraces, but they are also found on morainic hill country slopes. The limited regeneration of forest species may be related to unsuitable ground conditions and relative soil infertility, and perhaps a lack of, or inadequate, suitable seed sources.

Provided there is no major further modification, the community will return to tall forest as the number of forest plants slowly increases, but a period of time much greater than for E1 will be required.

(e) Future Prospects of Forest Remnants

Most of the present forest is cutover, dating from the early logging period of 60-80 years ago. Regeneration since then has been variable, but generally it is adequate to plentiful for stand replacement. Numerous rimu poles and small trees are emerging through the modified podocarp-hardwood forests on the hill country. On the glacial outwash terraces and elsewhere, there are many dense thickets of saplings and

poles, especially of kahikatea and red beech, often intermingled with the remains of the former canopy. Regeneration, not unexpectely, is less prolific in the only slightly modified stands where the canopy remains intact.

Unless protective measures are taken, the development of intensive farming will reverse this prospect. Already many forest remnants in the longest developed areas have been denuded of their understorey and ground layers. If this continues, the canopy will gradually disintegrate as recruitment fails to keep pace with mortality. The entire landscape character will change over future centuries until very little forest remains. Likewise the large-scale clearance of shrublands detracts from the potential area of future forest, and it may remove a protective edge from many forest remnants.

It is clear that long-term retention of the remaining forest vegetation on the Farm Settlement will require a positive committment and programme by those responsible for farm management. The most important requirement is protection from grazing, in particular by fencing.

2.5.5 Additional Notes on Vegetation of Bell Hill Farm Settlement and District

(a) Local Species Distributions

There are a number of forest plant species which have a restricted distribution on the Farm Settlement.

Kiekie (*Freycinetia banksii*) occurs on warm, west facing slopes on the Tertiary hill country below Molloys Lookout (S44: 959809) in Mawhera forest. It may extend to the adjacent lower altitude similar country on Blairs block, although none was seen. It also occurs on the northern slopes of nearby Mt Te Kinga.

Toro is for the most part confined to the warmer, north-facing slopes and ridges of Tertiary and morainic hill country. It is absent or very rare on the glacial outwash terraces and south facing hill country slopes.

Southern rata is common only on the Tertiary hill country of Blairs block, particularly on ridges. Elsewhere it only occurs as single trees or small groups on Loopline morainic hill country. Each occurrence is noted in the Forest Remnant Inventory Data in Appendix 7. The species is common on the adjacent much older geological formations in Mawhera and Otira-Kopara forests.

The orange-flowering rata vine (*Metrosideros fulgens*) is restricted to the Tertiary hill country on Blairs block and to some ridges and north facing slopes on Loopline morainic hill country.

(b) Cedar

Though usually a minor element, cedar is widespread in the vegetation on the Moana and Loopline outwash terraces, and on degradational alluvial terraces. It is absent from Moana and Loopline morainic hill country except on poorly drained sites and depressions, and from Tertiary hill country.

The cedar on the Farm Settlement has suffered heavy recent mortality. Dead standing trees are common in many places, often accounting for most of the cedar element in the vegetation. Seedling and sapling regeneration is generally poor, and it is apparent that cedar will be much less common in the forests of the future. Mortality appears greatest in highly modified canopies. There is little, if any, in the dense virgin rimu-cedar stand of r15.

The causes of this massive die-off of cedar, and its possible relationship to climatic changes (Wardle, 1978), requires further study. Of interest is the presence of many apparently healthy cedar trees in the southern rata, cedar, kamahi and quintinia forest on the higher hill slopes and ridges of the plateau immediately above and east of the Farm Settlement (about S52: 085742).

(c) Silver Pine

Silver pine was formerly common in the forests on the glacial outwash terraces of the Farm Settlement (Morgan, 1911). It was a favoured logging species because of its durability, and was probably subject to two or three or even more logging phases.

Today little silver pine remains, and then only as poles and small diameter trees. Restoration of communities in which silver pine is a naturally prominent element will take many centuries.

(d) Exotic Tree Plantations

There are two small plantations on the Farm Settlement, of contorta pine (*Pinus contorta*) and macrocarpa (*Cupressus macrocarpa*). Both are located adjacent to the Kotuku-Bell Hill Road, and are indicated by name on the vegetation map (Fig. 16).

2.6 FAUNA

2.6.1 Invertebrates

Because an invertebrate survey was not undertaken in this study, only general comments are presented.

Knowledge of the taxonomy, distribution and ecology of most New Zealand invertebrates remains imperfect. There are almost 10 000 species of insects recorded, and there are probably at least 20 000 species of terrestial arthropods in total, including undescribed forms (Watt, 1979). The native invertebrate fauna is characterised by a very high degree of endemicity at the specific and, to a lesser extent, the generic levels (Watt, 1975).

Lowland and montane native forests and shrubland are the most important habitats for New Zealand's invertebrates (Watt, 1975). International significance has been attached to the high degree of endemism in invertebrate species and to their predominant restriction to forest habitats (Raven, 1976). Most endemic invertebrates are confined to natural or slightly modified habitats and seem unable to adapt to altered environments (Watt, 1979). Destruction of the native habitat therefore causes local extinctions. In the absence of selection pressures by vertebrate predators, there has also been an evolutionary trend in some insect groups towards flightlessness and larger size which has made them vulnerable to introduced predators.

Through destruction of habitat and introduction of predators, Polynesian and European settlement in New Zealand has had a strong adverse impact on the invertebrate fauna (Ramsay, 1978; Watt, 1979). Many species have become extinct, and numerous others have become endangered especially in lowland habitats.

Given the dependence of New Zealand invertebrates on lowland and montane native forest habitat, it is likely that the formerly densely forested North Westland region once supported a rich and diverse invertebrate fauna. Invertebrates have undoubtedly been adversely affected by European settlement, particularly through widespread destruction of the primeval landscape. Unfortunately little enough is known of the former and present invertebrate fauna to enable detailed comparisons.

Perhaps surprisingly, native forest remnants support good invertebrate populations and offer valuable opportunities to invertebrate conservation programmes. For example, an Auckland study cited by Watt (1979) found that an area of 4.6 ha of second growth native forest and surrounding grasslands and gardens contained 646 species of native beetles (Coleoptera), 95 percent of them strictly confined to the forest remnant. Hence the preservation of even small remnants of regenerating native forest is vital to conserve local invertebrate communities and representative geographical populations, even though they may be too small to be of much value in the conservation of birds and vascular plants. The most important requirement is a stock-proof fence, to permit regeneration of native vegetation. Where there are several adjacent remnants, fencing to encompass them all is particularly useful by increasing the area of contiguous suitable habitat.

2.6.2 Mammals, Amphibians, Reptiles and Fishes

New Zealand has a somewhat depauperate terrestrial vertebrate fauna, reflecting its geological history and long isolation (Bull and Whitaker, 1975; Kuschel, 1975). Mammals are represented only by the short-tailed bat (*Mystacina tuberculata*) and long-tailed bat (*Chalinolobus tuberculatus*), amphibians by three primitive frog species (*Leiopelma* spp.), reptiles by the primitive tuatara (*Sphenodon punctatus*), 15 species of geckos (Robb, 1980) and 22 species of skinks (Hardy, 1977; Hardy and Hicks, 1980), and freshwater fish by 27 species (McDowall and Whitaker, 1975). Only the birds are well represented in the vertebrate fauna, with some 37 endemic species in a total of 65 (Bull and Whitaker, 1975).

Though not present now it is possible that the tuatara and perhaps one or more of the frogs occurred in the recent past in North Westland forests (Crook, 1975; Bull and Whitaker, 1975). The two bat species prefer forested habitats and were probably both present in the past. Both are now in very reduced numbers as a result of predation by introduced predators such as the black rat (*Rattus rattus*) (Bull and Whitaker, 1975). Skinks and geckos do not appear to have recovered from their elimination from the West Coast during the Pleistocene glaciations (Bull and Whitaker, 1975). They are currently found in a few scattered locations in Nelson and the West Coast, and their range has probably been reduced by introduced predators. Twenty of the

27 known native freshwater fish species occur in West Coast streams, rivers and lakes (McDowall, 1977). The native grayling (*Prototroctes oxyrhynchus*) was widely distributed during the early European period but is now probably extinct. Most species are widespread and of general occurrence outside forested areas but three, koaro (*Galaxias brevipinnis*), shortjawed kokopu (*G. postvectis*) and banded kokopu (*G. fasciatus*), are primarily restricted to forest catchments.

Many introduced vertebrates occur in North Westland (Gibb and Flux, 1973). Populations around the Farm Settlement are difficult to estimate without more detailed surveys. Red deer (*Cervus elaphus*) and wild goat (*Capra hircus*) are seen occasionally, especially near Mawhera forest. Possum (*Trichosorus vulpecula*), hare (*Lepus europeaus*), wild pig (*Sus scrofa*), stoat (*Mustela erminea*), black rat, Norway rat (*R. norvegicus*), wild cat (*Felix catus*) and house mouse (*Mus musculus*) are also found. Probably present are hedgehog (*Eurinaceus europaeus*), weasel (*Mustela nivalis*), ferret (*M. putoris*), rabbit (*Oryctolagus cuniculus*), two species of Australian tree frog (*Litoria raniformis* and *L. ewingi*), and brown trout (*Salmo trutta*).

2.6.3 Avifauna

2.6.3.1 Recent History of North Westland Avifauna. The avifaunal history of North Westland prior to the European period is poorly known, but the New Zealand situation is illustrative.

There have been great changes in the indigenous terrestial avifauna during the last thousand years or so. About 45 bird species are thought to have become extinct before about 1800 AD and are known only from subfossil remains (Ornithological Society of New Zealand, 1970). Among others they include at least six species of rail, seven waterfowl, four hawks and eagles, two snipe, a crow, and about 24 species of moas (Williams, 1962). The causes of their decline are difficult to define. Some were probably declining naturally, but undoubtedly habitat desctruction and other changes associated with Polynesian settlement were also responsible.

Because of the densely forested nature of North Westland, it is likely that Polynesian settlers were scattered and did not have a great impact on the avifauna. Extinctions of bird species were probably fewer and later than elsewhere in New Zealand. It is possible that a few of the smaller bush moas survived in the west of the South Island into the mid-nineteenth century (Scarlett, 1974).

Since European settlement began about 1800 AD, there have been further losses in the indigenous avifauna. At least five species and six subspecies have become extinct and some, such as laughing owl *(Sceloglaux albifacies)*, N.Z. Thrush *(Turnagra capensis)* and bush wren *(Xenicus longipes)* are now extremely rare or perhaps extinct (Bull and Whitaker, 1975). The continued existence of others, such as saddleback *(Philesturnus carunculatus)*, kakapo *(Strigops habroptilus)* and takahe *(Notornis mantelli)*, is precarious. The underlying causes of such changes are still not well understood, but certainly habitat destruction, introduced predators and competitors and possibly exotic avian diseases have been significant factors. On the other hand, Williams (1973) records a total of 34 introduced bird species which have become established since European settlement.

Such changes are well exemplified in North Westland. In an excellent account of the birdlife of the Lake Brunner district before the establishment of a significant European presence, Smith (1888) recorded a total of 32 birds of forests, rivers, and open spaces present in the area. These are listed in Table 4.

The pre-European birdlife of the district (including the Farm Settlement) was characterised by species richness[1] and abundance, and included nearly all forest inhabiting species of the South Island. However the impact of advancing European settlement was evident even in Smith's time. He reported a marked decline among what subsequently proved to be the most vulnerable species, including kakapo, S.I. thrush, S.I. kokako *(Callaeas cinera)* and S.I. saddleback. Others, such as kiwi *(Apteryx* sp.[2]), yellowhead *(Mohoua ochrocephala)* and bush wren were probably similarly affected. With the possible exception of the kiwi, all of these are now absent from the Lake Brunner district.

A second phase in wildlife destruction probably occurred following massive forest clearance operations beginning about 1890. Birds dependent on large tracts of indigenous forest or forest-surrounded rivers

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1. Except where otherwise indicated, species richness in this report refers to number of species present. It is distinct from species diversity, which is a measure of both the number of species present and the evenness of distribution of individuals among these species (McLay, 1974). The two concepts are not always clearly differentiated in the literature.

2. Considerable misidentification of the three kiwi species occurring in the South Island has occurred in the past (Roderick, 1979). It is probable, even likely, that Smith's report of a S.I. brown kiwi *(A. australis)* is a mistaken identification for the great spotted kiwi *(A. haastii)*. The great spotted kiwi is still found in the nearby Crooked River valley, and perhaps even on the Farm Settlement (see r65, Forest Remnant Inventory Data, Appendix 7).

TABLE 4: Birds of Forests, Rivers and Open Spaces Recorded by Smith (1888) in Lake Brunner District

1.	S.I. (Brown) Kiwi	2.	Kakapo
3.	S.I. Bush Wren	4.	S.I. Thrush
5.	S.I. Kokako	6.	S.I. Saddleback
7.	Yellowhead	8.	Blue Duck
9.	N.Z. Falcon	10.	S.I. Kaka
11.	Red-Crowned Parakeet	12.	Yellow-Crowned Parakeet
13.	S.I. Rifleman	14.	S.I. Robin
15.	Western Weka	16.	Harrier
17.	Long-Tailed Cuckoo	18.	Shining Cuckoo
19.	Tui	20.	Bellbird
21.	Silvereye	22.	Grey Warbler
23.	Kingfisher	24.	Yellow-breasted Tit
25.	S.I. Fantail	26.	N.Z. Pigeon
27.	Pukeko	28.	Morepork
29.	Grey Duck	30.	Southern Black-backed Gull
31.	Little Shag	32.	Black Shag

suffered most. Today, blue duck *(Hymenolaimus malacorhynchos)*, N.Z. falcon *(Falco novaeseelandiae)*, S.I. kaka *(Nestor meridionalis)*, and red-crowned and yellow-crowned parakeets *(Cyanoramphus novae-zelandiae* and *C. auriceps)* are very uncommon or absent from the district. Where present, S.I. rifleman *(Acanthisitta chloris)* and S.I. robin *(Petroica australis)* are confined to the larger forest tracts.

The S.I. fernbird *(Bowdleria punctata)* was not recorded by Smith although it may have been present. Its current widespread but patchy distribution in the district is closely related to increases in its pakihi habitat following forest destruction. Brown creeper *(Finschia novaeseelandiae)*, also not recorded by Smith, was probably present in his time and still occurs today.

In summary, of a total of 34 bird species recorded in the Lake Brunner district before the advent of Europeans, 14 species have become locally extinct or are now found only as occasional visitors. The future of nearly all remaining species however appears reasonably secure provided their habitat is protected. They have a comparatively higher reproductive capacity and dispersal capability (Spurr, 1979b) and are still fairly common in the district.

2.6.3.2 Present Avifauna of North Westland. Recent wildlife surveys of North Westland forests have shown a previously unrecognised diversity and abundance of native, forest-dwelling birds (Crook and Best, 1974 and 1975; Best and Harrison, 1976; Crook *et al.*, 1977; Dawson *et al.*, 1978; Park and Bartle, 1978), although no very rare birds were found. Bird population densities were recorded which are comparable with those in areas traditionally considered to be richly endowed with birds, such as the sanctuaries of Kapiti and Little Barrier Islands and North Island broadleaf forests (Crook and Best, 1974). Many less common species, such as great spotted kiwi, kaka, parakeets and robin, occur in good numbers in the region.

The surveys show the quantitative composition of the bird fauna to be particularly diverse, and that it varies between forest types and from region to region (Crook *et al.*, 1977). There are different assemblages of birds in different regions, reflecting the unique combination of largeness, diversity and continuity of lowland forest habitat in the region. In the mid-Grey Valley very high numbers of birds and species were recorded in the Card Creek, Nelson Creek and Flagstaff areas (Crook and Best, 1974; Best and Harrison, 1976).

Significant differences are apparent between the podocarp-beech forests north of the podocarp-beech ecotone and the pure podocarp forests to the south.

It is considered that only the protection of representative areas of such habitat and the provision of corridors between them to provide continuity and prevent genetic isolation will ensure the continued existence, evolution and diversity of the avifauna (Best and Harrison, 1976).

2.6.3.3 Avifauna of Bell Hill Farm Settlement. The following section is based on field work carried out on the Farm Settlement between January - May 1979 and June - July 1980.

(a) Forest Dwelling Native Birds.

Because the native avifauna of the forest remnants of the Farm Settlement is not of great regional significance, the use of intensive systematic population sampling methods such as the five-minute bird count (Dawson and Bull, 1975) was not considered justified in the present study. Rather, quantitative data collection was restricted to a species list for each forest remnant, together with some indication of numbers. For infrequently observed birds the actual number of birds was recorded, but for the more common species only a rough estimate of birds seen or heard was noted.

The conditionsunder which such counts were taken were extremely varied. Variable factors included: weather; amount of time spent in each area; use or not of taped bird calls and/or a polystyrene-on-glass squeaker to attract birds; and use of binoculars or personal optical glasses to identify distant birds. Records may also be influenced by seasonal variations in bird conspicuousness, particularly during the moulting period when many species are seldom heard or seen. Seasonal migration by some species is another possible source of variation[1].

For these reasons it is considered that direct comparisons of forest remnant avifauna populations using the data collected would not be valid. However, as considerable effort was made to record all bird species in each bush remnant, bird species richness can be and is used as an index for comparative purposes.

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1. Seasonal migration was particularly evident in the surveys of the newly acquired part of Blairs block in the winter of 1980. At the time long-tailed cuckoo *(Eudynamys taitensis)*, shining cuckoo *(Chrysococcyx lucidus)*, tui *(Prosthemadera novaeseelandiae)* and N.Z. pigeon *(Hemiphaga novaeseelandiae)* were all noticeable by their absence or low frequency of occurrence.

Island biogeography studies have shown that there is a close correlation between bird species richness and available habitat area (Diamond, 1975). In New Zealand, Dawson and Hackwell (1978) have demonstrated that such a relationship holds for the native forest bird species in large indigenous forest areas. That a similar correlation holds for the small forest remnants on Bell Hill Farm Settlement is evident from Fig. 11, a histogram relating the number of forest-dwelling native bird species to the size of forest remnants. The data used are presented in Appendix 3. No regression has been established for the relationship because of the lack of standardisation in data collection.

These results conform to what might be expected from island biogeography theory, and are similar, although not directly comparable, to those of Dawson and Hackwell (1978) for much larger forested areas in New Zealand. They illustrate well the principle that small areas of habitat support fewer species of animals than large areas of the same habitat. Those birds with relatively specific habitat requirements, such as robin, rifleman, kaka, parakeets and kiwi, are either absent from Farm Settlement forest remnants or are of very restricted occurrence.

Island biogeography studies also suggest that the number of species in isolated habitats such as forest remnants is an inverse function of the degree of isolation. However Mawhera forest, arguably the most modified forest in North Westland, supports only a slightly wider range of bird species and its role as a potential source of colonists for Farm Settlement forest remnants is therefore limited. Possible exceptions include the N.Z. pigeon and tui, which are often found in forest remnants adjacent to Mawhera forest but are rarely seen in more isolated but otherwise comparable remnants. Similarly, robin and rifleman are restricted to forest remnants contiguous with Mawhera forest or the Arnold River Scenic Reserve.

A measure of the distribution of individual species is provided by their frequency of occurrence (that is, whether the species is present or absent in the sample area). Table 5 shows the frequency of the 15 forest-dwelling native birds recorded on the Farm Settlement.

The most commonly found species are the predominantly insectivorous S.I. fantail *(Rhipidura fuliginosa)*, grey warbler

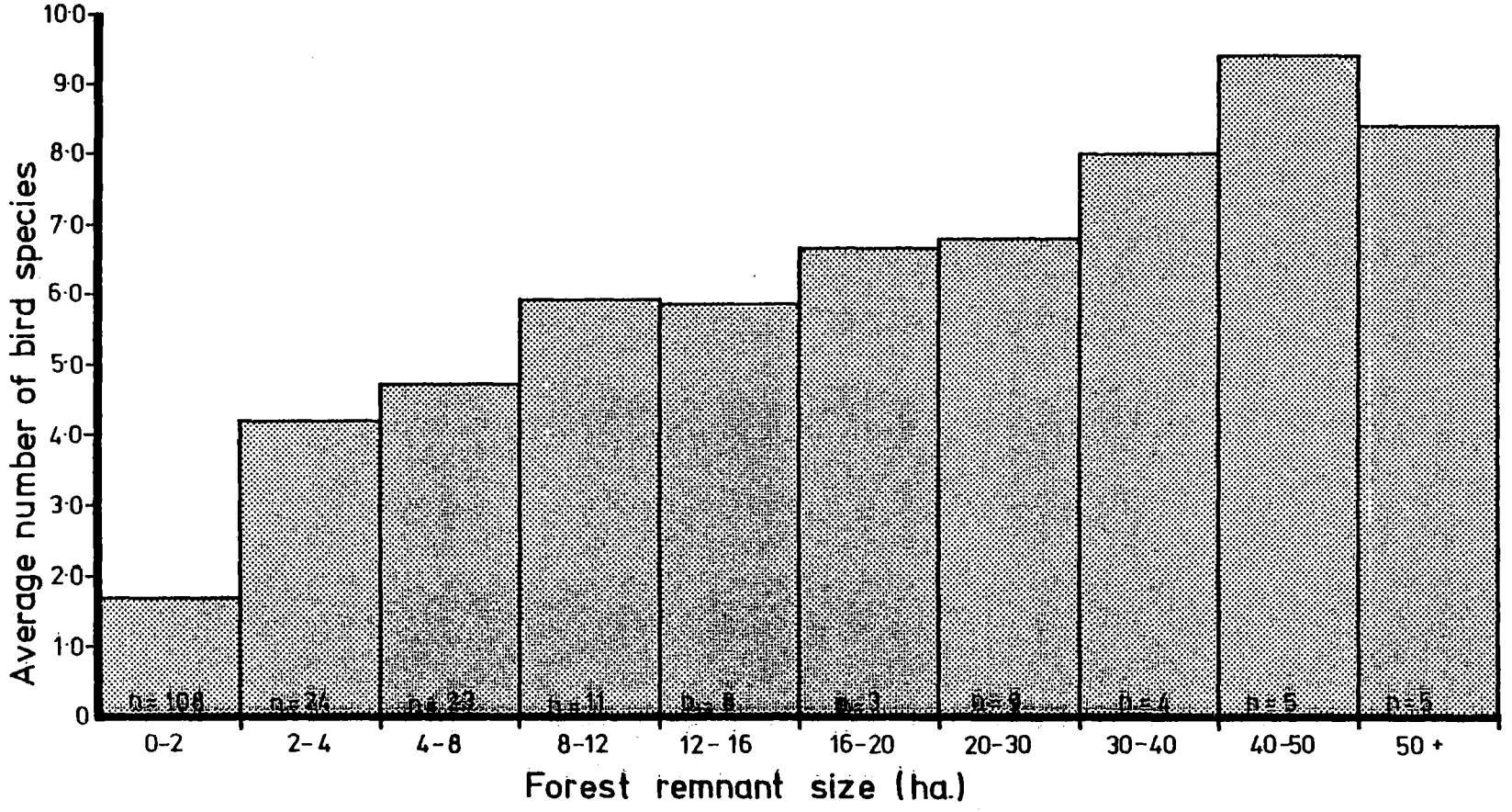

FIGURE 11: Average Number of Native Forest Bird Species in Relation to Forest Remnant Size, Bell Hill Farm Settlement.

1. No data are available for four remnants
2. X-axis (forest remnant size) has unequal class size.
3. Number of remnants per size class is shown as n.
4. Average number of bird species is under-estimated if not all species in a remnant were recorded during surveys. Very small remnants are likely to be more seriously under-estimated than larger ones as less time was spent in them.

(Gerygone igata), and silvereye *(Zosterops lateralis)*. They occur in over half of all remnants including the smallest, which indicates their adaptability to living in scrub and regenerating cutover forest. Bellbird *(Anthornis melanura)*, yellow-breasted tit *(Petroica macrocephala)*, western weka *(Gallirallus australis)*, tui brown creeper and N.Z. pigeon are less commonly found, more likely than not in larger forest areas. Of restricted distribution are the kingfisher *(Halcyon sancta)*, robin and rifleman. The kingfisher is usually found around forest-surrounded streams, and the robin and rifleman occur only in large forest remnants adjacent to Mawhera forest or the Arnold River Scenic Reserve. Of the other species, the nocturnal morepork *(Ninox novaeseelandiae)* and the migratory long-tailed cuckoo and shining cuckoo were very inconspicuous at the time of this survey and are probably considerably more common than indicated. The shining cuckoo for example is silent after mid-February until it leaves in late summer for the Bismark Archipelago and Solomon Islands.

Forest-dwelling native birds on the Farm Settlement are an integral part of the forest remnant ecosystems. Fruit-eaters (pigeons, silvereyes, bellbirds, tuis) are essential agents of seed dispersal for many tree and shrub species, honey-eaters (tuis, bellbirds) may be important pollinators of some plants, and insectivorous birds (the majority of species) have a major impact on the invertebrate fauna. Protection of the avifauna is therefore essential for forest remnant conservation (and *vice versa*).

In summary, the species richness of the forest-dwelling native avifauna on the Farm Settlement is restricted. The small and scattered nature of forest remnants means the less common species of North Westland are either absent or present only as occasional visitors or in very low numbers. There appears a strong positive relationship between species richness and forest remnant size, and the results also suggest that size is an important factor in determining what species actually occur in forest remnants. The abundance of most species present may be described as moderate to high. The avifauna of the Farm Settlement is a significant element of the forest remnant ecosystems and is important in the North Westland context in providing continuity among populations of surrounding forest areas.

TABLE 5: Frequency of Occurrence of Forest Dwelling Native Birds in Forest Remnants on Bell Hill Farm Settlement.

	Ruru	Weka	Blairs	Total
Fantail	64	42	24	130
Grey Warbler	63	37	19	119
Silvereye	52	38	19	109
Bellbird	43	22	16	81
Tit	35	24	20	79
Weka	31	15	13	59
Tui	24	7	9	40
Brown Creeper	23	8	8	39
N.Z. Pigeon	11	13	7	31
Kingfisher	5	-	1	6
Robin	3	1	-	4
Rifleman	1	-	3	4
Long-tailed Cuckoo	3	-	-	3
Morepork	1	-	1	2
Shining Cuckoo	1	-	-	1
Total number of remnants	108	62	34	204

Note: No data were recorded for four remnants.

(b) Other Avifauna

There is a considerable variety of other birds on the Farm Settlement. A total of 42 species (including the 15 already listed) was recorded during the present survey, and several others may be present.

Of the native species, the N.Z. pipit *(Anthus novaeseelandiae)* and spur-winged plover *(Vanellus miles)* are found in open grasslands, where the harrier *(Circus approximans)* and southern black-backed gull *(Larus dominicanus)* may also be seen occasionally. Fernbirds occur in pakihi vegetation and shrublands. Keas *(Nestor notablis)* are sometimes seen flying across the Farm Settlement. Introduced species of grassland and shrubland include skylark *(Alauda arvensis)*, greenfinch *(Carduelis chloris)*, goldfinch *(C. carduelis)*, redpoll *(C. flammea)*, chaffinch *(Fringilla coelebs)*, yellowhammer *(Emberiza citrinella)*, house sparrow *(Passer domesticus)*, starling *(Sturnus vulgaris)*, blackbird *(Turdus merula)*, song thrush *(T. philomelos)*, hedge sparrow *(Prunella modularis)*, white-backed magpie *(Gymnorhina tibicen hypoleuca)* and black-backed magpie *(G. t. tibicen)*. The following birds of water or swampy habitats were also recorded: black shag *(Phalacrocorax carbo)*, little shag *(P. melanoleucos)*, grey duck *(Anas superciliosa)*, mallard *(A. platyrhynchos)*, paradise shelduck *(Tadorna variegata)*, welcome swallow *(Hirundo tahitica)*, pukeko *(Porphyrio porphyrio)*, white-faced heron *(Ardea novaehollandiae)*, and Australian little grebe *(Tachybaptus novaehollandiae)*.

Of special interest is the occurrence of the S.I. fernbird on the Farm Settlement. Fernbirds are an endemic New Zealand species. They are poor fliers, small and unobtrusive, and are rarely seen. Although still widely distributed in New Zealand, they have become localised and greatly reduced in numbers through loss of habitat by land development and swamp drainage. They are usually found in open shrublands and swampy pakihi vegetation, with a marked preference for areas with low, dense ground vegetation and emergent shrubbery (Best, 1979). Fernbirds in North Westland are a little unusual in that they may have expanded their range there following forest clearance. By the same token however, Westland is now the last major stronghold of the S.I. fernbird (Owen, 1980).

On Ruru block, 5-6 birds were recorded in the Deep Creek pakihi but there may well be two or three times that number spread over the pakihi on the Farm Settlement and the adjacent Deep Creek ecological area. A further 14 birds were found widely dispersed on Ruru block. Twenty-eight fernbirds were recorded on Weka block, all but one of them in the partly developed area between the new Deep Creek road and Deep Creek. There were 26 birds noted on Blairs block, principally on the recently acquired parts in the south-east and north-west of the block. Because fernbird habitat was not exhaustively searched and the survey included the quiet moulting period, the total number of fernbirds is certainly higher and may constitute a significant proportion of the regional population.

The future of fernbirds on the Farm Settlement is precarious. Undoubtedly the population has already declined considerably as fernbird habitat has been converted to pasture. Further decline is almost certain. Most of the present habitat will become farmland, and forest regeneration in the remainder will exclude fernbirds when the canopy grows more than 4-5 m high.

Also of interest is the presence of the Australian little grebe. Common in Australia, the little grebe was first reported in New Zealand in 1968 (Falla *et al.*, 1979) and now appears to be establishing itself. One of the first recorded breeding attempts occurred in early 1978 by a pair on a small pond on the Farm Settlement (map reference, S52: 055743), but without final success (Lauder and Murray, 1978). During the 1978-79 summer the resident pair returned. They hatched two chicks in early February 1979, one of which disappeared shortly afterwards. The other chick developed rapidly and, preceded by its parents, left the pond in late April. Two grebes returned to the pond during the 1979-1980 summer, but there was no evidence of breeding and they again left at the approach of winter (Lauder, 1980). The birds were not sighted during the 1979 winter but three were recorded on Lake Brunner during the winter of 1980. The presence of three birds suggests breeding during the 1978-1979 season was successful.

CHAPTER 3

ASSESSMENT OF NATURE CONSERVATION VALUES

3.1 NATURE CONSERVATION

3.1.1 Introduction

Extinction is the ultimate fate of all species - so why conserve nature?

There are many arguments and values involved in nature conservation (or in its basic form, the protection of natural areas). They are closely intertwined but may be broadly categorised as economic, educational, recreational, aesthetic and spiritual, and scientific. In this, a scientific report, the first four are outlined only. More detailed attention is given in the following section to scientific justifications for nature conservation.

Economic: Plants and animals are important sources of food and fibre on which the human race relies. They are also reservoirs of a vast range of compounds and products which are actually or potentially useful to humans. Since the economic value of a species can never be foreseen, the protection of species in natural areas is a means of safeguarding potentially valuable living resources.

Educational: Natural areas can play an important educational role in a number of subject fields, particularly the biological and earth sciences. As human populations become more urbanised, the need to experience and understand natural phenomena and processes appears to increase, particularly in more affluent societies. For many, such experiences can only be realised through educational systems. Education too can be closely associated with scientific investigation.

Recreational: Recreational use of natural areas is expanding rapidly in more affluent societies, as people seek to enjoy increasing leisure time. For many it may also be an escape from the pressures of living in a highly urbanised environment. Current social research is attempting to comprehend the human needs that are served by such behaviour. Recreational and worklife behaviour may inter-relate with common human needs.

Aesthetic and Spiritual: The beauty of Nature, its aesthetic value, has always appealed to humans' sensitivity and imagination, and has been an inspiration for literature and fine art. The preservation of natural areas recognizes not only beauty (as in preservation of art objects), but also the uniqueness and irreplaceability of species as products of the evolutionary process. There is also an ethical consideration. Expressed in simple form, many people believe that every species has a right to an evolutionary existence in a natural environment free of thoughtless acts of habitat destruction and over-exploitation by humans. Our natural heritage is worthy of protection, and we are its custodians for future human generations or, in a religious context, stewards of nature for the creator and end of nature. In some sense then it may be argued that we forego human dignity and responsibility insofar as we neglect to conserve nature.

The force of such arguments in situations will vary, particularly in relation to different people's perceptions and values.

3.1.2 Scientific Rationale for Nature Conservation

The principal scientific objectives of nature conservation may be summarised as: (a) study and understanding of nature and natural processes; (b) provision of baselines for study and understanding of changes in modified ecosystems; (c) maintenance of genetic diversity; and (d) protection of rare and endangered species (Atkinson, 1961; Bassett, 1977).

(a) Study of Nature and Natural Resources.

Understanding of the world and how it works is at the basis of past, present and future human technological and social development. Basic knowledge about natural systems, processes and interrelationships, of which much remains to be learnt, is thus of more than academic interest.

Fundamental scientific research in a wide range of fields, including taxonomy, genetics, evolution, ecology, biogeography, geology, soil science and others, is dependent on use of natural areas as "outdoor laboratories". The cost of lost scientific opportunities through destruction of natural habitats and extinction of species may be incalculable, but is nonetheless real. For instance, there is no telling how long the development of evolutionary theory would have lagged had the unique fauna of the Galapagos Islands been destroyed before Darwin's voyage there in 1835 (Eckholm, 1978).

In the future the importance of protected natural areas will be magnified as remaining relatively unmodified landscapes are lost through the expanding demands of human societies. Greater scientific understanding will be important in more intensive forms of resource use, particularly in fields such as minimisation of environmental damage and the sustained yield management of natural resources. In a country like New Zealand so dependent on the wise use of its living resources, such understanding is essential.

(b) Baselines for Study of Changes in Modified Ecosystems.

Moir (1972) suggests the principal justification of natural areas is their role as bench-marks for assessing the extent of society's impact upon diverse land, lake, river, estuary and coastal environments. Long-term baseline ecological research in natural areas establishes the bench-marks or reference points against which comparisons with modified ecosystems can be made. Such information is necessary in assessing environmental quality, and in aiding resource managers to predict the consequences of alternative uses of land and other natural or cultivated resources. These principles are at the heart of the current Man and Biosphere programme of UNESCO for Biosphere Reserves (DiCastri and Loope, 1977; O'Connor and Molloy, 1979).

To be effective as reference points, natural areas should be typical of large areas that will be or have been developed. Potential uses are many and varied. For example, comparison of data from virgin and logged forests can provide information on forest successional processes, and on the effects of forest removal on hydrological performance and the physical and chemical properties of soils (Bassett, 1977). Natural areas therefore become reference points for monitoring the processes of modified or cultural areas ahd for assessing the sustainability of the chosen culture.

(c) Maintenance of Genetic Diversity.

The importance of preserving genetic diversity is most apparent in agriculture and forestry, where shrinking gene pools of numerous plant and animal species threaten the basis of future genetic breeding programmes (Frankel and Bennett, 1970b; Eckholm, 1978). The world-wide spread of modern agricultural methods and the use of selected high-yielding seed strains has greatly increased production, but is has also entailed the substitution of a vast range of locally evolved crop varieties by a limited range of bred varieties. The consequent loss of

genetic diversity, particularly in traditional centres of crop diversity such as in the Middle East and central Asia, is greatly reducing the resource available to plant breeders. Similarly the future of production forestry is being undercut as natural forests and genetic resources are depleted, although the situation is not as urgent (Callaham, 1970).

Genetic diversity constitutes the raw material for a variety of industrial, medical, biological and other products crucial to technologically advanced societies. Only a fraction of the earth's species has been screened for possible uses, so when a species becomes extinct the cost in terms of foregone opportunities may never be known. Moreover the loss is irreparable. It is highly improbable that balanced gene complexes, which are the consequence of long-term evolutionary selection, can be assembled by mutation breeding techniques (Frankel and Bennett, 1970b).

The possible global consequences of losses of genetic diversity are poorly understood but may be far from inconsequential (Vida, 1978; Eckholm, 1978). The ability to adapt to environmental conditions, presently changing at a rate unknown in earlier evolutionary history, is dependent on wide genetic diversity. If taxa lack diversity and cannot adapt and evolve, their fate is extinction. In the late twentieth century, characterised by increasing spread of human societies, wide dissemination of toxic chemicals and pollutants, and increasing rates of habitat destruction, the rate of species disappearance has risen sharply and now certainly surpasses the rate at which new species are evolving. A substantial proportion of all plant and animal species on earth today (estimated to number between three and ten million) is threatened with extinction if present trends continue. The danger is everywhere but is greatest in the tropics. The moist tropical rainforests, which support a remarkable diversity of species (up to one million in the Amazon Basin alone), have been reduced in extent by more than 40 percent, and the destruction is continuing apace.

Evolution will no doubt continue under such conditions, but in a grossly distorted manner. The loss of so many species and the parallel effects of continuing causal forces threaten a basic and irreversible alteration in the nature of the biosphere. Its continuing capability to support human societies may then be called into question.

(d) Protection of Rare and Endangered Species

Species may be rare because of specialised habitat requirements or relict distributions, or because they may be the focus of some direct or indirect human pressure. Some rare species are recent arrivals which have not yet spread, and others are at the limits of their climatic range. Rare species are thus often of great ecological and biogeographical importance, and their conservation is considered important (Ratcliffe, 1977).

Species loss may induce deleterious change in the natural balances of ecosystems of which they are an integral part. Removal of even a minor element in a community can have far-reaching effects on all members.

The protection of rare and endangered species is also in part a special case of the protection of genetic resources. Priority is given to rare and endangered species because they are, by definition, at risk of extinction. The loss of a species is of a higher order than if only part of a species' range of diversity is lost. Similarly the loss of a complete genus is greater than a species, a family greater than a genus, and so on.

3.2 STRATEGIES OF NATURE CONSERVATION

3.2.1 General Requirements in Relation to Objectives

Conservation strategies must be cognizant of the relevant objectives and their interrelationships, and of the nature of what is being conserved.

The first two objectives outlined in the foregoing rationale, the study of nature and natural processes, and provision of baselines for the study of changes in modified ecosystems, are closely related and their requirements are similar in many respects. Simply, they require a comprehensive system of natural areas to preserve representative samples of the full range of landforms, biota and natural phenomena within a region (Jenkins and Bedford, 1973). Such natural areas should be relatively unmodified, and sufficiently large and remote to be protected from human influences. Positive management may be necessary to keep natural areas free from human influences(and scientific work should also respect this requirement). Dasmann (1973) has proposed the concepts of strict natural areas and managed natural areas, differentiated by

prescribed levels of human interference with natural evolutionary or with perturbatory processes. Seral communities may require managed natural areas for their perpetuation.

Natural areas are thus available for basic research in many scientific disciplines. They can be used to establish long-term baseline and environmental quality measurements for their comparison with similar modified ecosystems through such methods as ecosystem analysis. Their value for basic research may be enhanced by the inclusion of large areas covering different ecosystems, of areas of the highest possible diversity, of relatively rare species, communities and ecosystems, of seral communities, of ecotones or transitional communities of ecological and biogeographical significance, and of communities along ecological gradients such as latitude and altitude. A variety of modified ecosystems may be included to facilitate comparison with natural reference sites. These may be used as baselines to assess changes in modified systems and may also act as buffer zones to protect the core natural area from human influence.

For conserving genetic resources, the nature of the material and the objective and scope of its conservation are important. Dwindling crop genetic resources have recently become a major concern to plant geneticists, and programmes are now underway to explore and protect the genetic diversity of many economically important species (Frankel and Bennett, 1970a; Frankel and Hawkes, 1975). The short-term response to this urgent situation has been to attempt to establish gene banks, to store collections of seeds, pollen and tissue cultures. However, it is clear that the long-term conservation of the genetic resources of wild biota is generally feasible only within natural communities in a state of continuing evolution. A community in balance with a stable environment, but subject to the general vagaries of natural environments, is the ideal model of long-term genetic conservation[1] (Frankel, 1970; Jain, 1975).

Genetic conservation is thus a part of nature conservation, but it goes further than most nature conservation programmes in aiming at a wide genetic base rather than populations and ecosystems. Its principal

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1. An important implication of genetic reserves is that their dynamic evolutionary character will ultimately preclude preservation of the form recognised at the time of reservation.

requirement is a representative natural area system encompassing population samples along ecological gradients, such as altitude, latitude and soil fertility, to provide a spectrum of genetic variability. The possibility of local population genetic differentiation (Miller, 1979) needs also to be considered.

Specifications for genetic conservation must be cognizant of the nature of breeding processes (Connor, 1979). For instance, breeding opportunities in many New Zealand plants are quite narrow, and so a relatively low number of individuals may be required for species' survival at a particular site. A species which is confined to a particular area can clearly be preserved in its entirety, as for example the Castle Hill buttercup *(Ranunculus paucifolius)* (McCaskill, 1979). However, it is impossible to preserve the whole genetic complement of a widespread species, and the best option in such instances is to preserve a representative range of genetic variability. Large areas may be necessary for forest trees, on account of their size, longevity, method of reproduction (wind pollination for all conifers and many hardwoods) and the often exceptional magnitude of genetic variability in natural forest populations (Richardson, 1970). Preservation of animal genetic resources similarly depends on species' breeding behaviour and also on their interaction with other aspects of animal behaviour such as seasonal feeding behaviour. For some animals therefore the area needed for effective preservation of genetic resources may be very large.

The causes of rarity and/or declining numbers in rare and endangered species should be the basis for determining what protective measures, if any, are appropriate. In many instances active management of habitat or population biology may be necessary to increase survival rates. However, the most effective and often the least costly strategy will usually be the protection of an adequate range of suitable habitat. The area required may be comparatively little for some plant species, but relatively large for many birds and migratory animals. As a corollary, habitat protection is usually the most effective means of preventing species falling into the rare or endangered category.

In short, there are specific instances, such as the protection of dwindling crop resources or of species on the verge of extinction, in which a direct approach and intensive measures may be required. However, there is little doubt that the most effective and least costly conservation strategy integrating all the above objectives is centred

on two principles: the protection of substantial representative natural areas, and the protection of habitats (Jain, 1975; Helliwell, 1976: Ratcliffe, 1977). It is likely that a system of representative reserves will exclude some specific characteristics of value such as rare and endangered species and their habitats. These should therefore be protected in supplementary unique reserves.

3.2.2 Technical Factors affecting Selection and Design of Nature Reserves

(a) Introduction

Suggestions on the total extent of reserves devoted primarily to nature conservation in a country vary widely. The International Union for the Conservation of Nature and Natural Resources (I U C N) has recommended a value of five percent (cited in Slatyer, 1975), a value regarded by Slatyer very much as a minimum. Helliwell (1976) suggests a larger proportion, of the order of 20 percent. The actual value will however vary greatly according to circumstances. In relatively unmodified regions where there is a wide range of alternatives for reserves, a generous allocation covering the full range of diversity and perhaps compensating for poorly endowed neighbouring regions may be possible. In regions with a long history of human occupation and disturbance the choice will be restricted and indeed may not exist. In many cases integration with other compatible land uses such as recreation, water conservation and catchment protection, and some forms of tourism, may be desirable to reduce social costs. Recognition of nature conservation as a valid and legitimate use of land and other resources is now growing (Moir, 1972; Conway, 1977; Ratcliffe, 1977; O'Connor and Molloy, 1979), and nature conservation now formally exists as one of several major land uses in New Zealand official high mountains policy (New Zealand Government, 1979). Social, legal political and other factors in resource allocation must be recognised as well as resource suitability for nature conservation in any plan for allocation of resources, especially involving integration of uses (O'Connor, 1978).

Within such a perspective, a systematic approach to the selection and design of reserves is needed to optimise protected nature conservation values. An ideal approach is the use of defined scientific criteria to

assess and rank the nature conservation value or capability of all land within a region, with a view to identifying the areas or features most worthy of reservation. Such criteria have general validity however, and as many as are appropriate may be used in other endeavours such as assessing the value of a potential reserve or the adequacy of a system of existing reserves.

Two fields of scientific study, island biogeography and population genetics, warrant more detailed exposition for their potential provision of criteria for selection and design of reserves.

(b) Island Biogeography

The presentation here draws substantially on Diamond (1975 and 1976). Oceanic islands are areas where terrestrial and freshwater plant and animal species can exist, but which are surrounded by habitat in which the species can survive poorly or not at all. The sea consequently represents a distributional barrier. There are many analogous situations not actually involving oceanic islands which possess the same distributional significance for survival of species. Obligate alpine plants, for instance, may be restricted to isolated mountain tops by the surrounding "sea" of lowland. Similarly the analogy can be applied to species restricted to natural habitats and unable to disperse through surrounding modified ecosystems. Island biogeography theory can therefore be applied to a system of natural habitat reserves surrounded by altered habitats. In a world in which natural habitats are shrinking in area and becoming increasingly fragmented in distribution, island biogeographic analysis is a potentially valuable tool in optimising the function of reserves in saving species.

Empirical studies[1] of island archipelagoes show a direct relationship between the number of species[2] an island can support in a stable state, and the area of the island (Terborgh, 1974; Diamond, 1975; Diamond and May, 1976). The relationship is usually of a double logarithmic form:

$$S = S_o A^z$$

where S is the number of species, S_o is a constant for a given species group in a given archipelago, A is the area of the island, and z is a

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1. To date studies have concentrated on vertebrate fauna, particularly birds (Simberloff and Abele, 1976). It is not known to what extent invertebrates or plants conform to island biogeographic predictions, although species diversity and the range of species is clearly related in part to available habitat area.
2. In island biogeography literature the number of species is usually referred to as "species diversity", rather than species richness as used previously in this report. Species diversity is retained in this section in preference to species richness to maintain concordance with the relevant literature.

variate usually within the range 0.18-0.35. A rough rule of thumb, corresponding to a z value of 0.30, is that a tenfold increase in island area means a twofold increase in the number of species. Expressed another way, if 10 percent of a natural habitat is retained, only 50 percent of the species dependent on that habitat will survive in the long-term.

For islands of similar areas but at different distances from continent or large island sources of colonisation, there is a simple inverse relationship between distance and number of species. For example, the number of bird species on southwest Pacific islands decreases by a factor of two for each 2600 km of distance from New Guinea (Diamond, 1975). For plants or animals with weaker dispersal powers than birds, the fall-off in species number with distance would be even more rapid.

The mechanisms behind the area and isolation effects are apparently related to immigration rates of new colonists and extinction rates of extant species. For an island of given size and isolation, the number of species is apparently set by, or approaches, an equilibrium at which the number of colonisations equals the number of extinctions. The more isolated the island is, the lower the immigration rate and hence the chance of making good any extinction. The larger the island is, the lower the risk of extinction through fluctuating population numbers and the greater the variety of resources and habitats for different species to exploit. The steady state number of species on an island occurs when immigration and extinction rates are equal. The identities of those species need not be constant over time however.

These results can be applied with caution to reserves of natural habitat surrounded by humanly modified habitats[1]. The long term number of species in a reserve will increase with increasing reserve size, and will decrease with increasing isolation. Thus if 90 percent of the area is converted into other habitats and the remaining 10 percent is reserved, approximately half the species restricted to that habitat will survive and the remainder will eventually disappear. If the remaining

1. It should be noted that the two situations, although analogous, are not equivalent (Terborgh, 1974). Isolated natural habitats on the mainland are more likely to be subject to invasion by species in adjacent habitats (that is, high immigration rates of "weedy" species). Hence species dependent on the natural habitat have a higher chance of being displaced. Additionally, immigration sources for species restricted to the natural habitat will dry up as adjacent modification continues, thus disturbing the immigration-extinction equilibrium still further (Pickett and Thompson, 1978). On the other hand, modified habitats between reserves may not represent a distributional barrier of the same significance as an ocean, and indeed may support many of the species in the reserve.

habitat area is divided the number of species saved will be less, even more so if the parts are relatively isolated.

The rate of decline in the number of species in a reserve representing some fraction of the former extent of a natural habitat can also be assessed. A reserve will initially support most, but not necessarily all, the species restricted to the original area of habitat. As the natural habitat outside the reserve is modified, the number of species becomes supraequilibrial (that is, more than the reserve as an island can support). This situation is analogous to "land-bridge islands", islands which were formerly linked to continents or larger islands and shared their floras and faunas but which have become isolated following post-glacial sea level rises. Avifauna studies show that the "relaxation rate", or the rate of species loss, is directly related to the area of the island. Larger land-bridge islands still have more species after 10 000 years than the equilibrium number predicted for their area from the species-area relationship, but smaller land-bridge islands appear to have lost their entire excess of bird species (Terborgh, 1974; Diamond, 1975). Hence reserve size is an important factor in the rate of species loss. Small reserves will not only ultimately contain fewer species but they will also lose supraequilibrial species at a higher rate.

Species are differentially susceptible to extinction processes on islands and in reserves. Analysis of the presence or absence of species on different sized islands shows that different species have different minimum area requirements for survival. Species with low extinction rates and high dispersal capabilities such that they can recolonise areas from which they have become locally extinct are the most likely to survive in a reserve system. However, some species appear naturally prone to extinction. These include species characterised by very specialised habitat requirements (often endemics), by major population fluctuations related to periodic changes in food or other resource supply, by strong competition or predation pressure, by poor dispersal and colonisation ability, by naturally low populations related to high trophic level and very large territory requirements, and by low natural rates of increase. To minimise the risk of extinction, a reserve which is isolated from outside immigration sources should be sufficiently large so that internal recolonisation sources for all species are maintained despite natural disturbance patterns (Pickett and Thompson, 1978).

Island biogeography studies suggest the application of geometric design principles for reserves[1]. These principles are illustrated in Fig. 12. (Bracketed upper case letters in the subsequent text refer to this Figure.)

Given constancy of other factors, these studies reinforce the significance of area already indicated from consideration of objectives. A large reserve is better than a small one as it will support more species at equilibrium and will suffer lower extinction rates (A). Large size is critical to the survival of vulnerable, extinction-prone species.

Spatial distribution of reserves is significant. A single reserve is generally better than a number of smaller reserves of the same total area (B). Distributional barriers of modified habitat reduce the effective area available to many species. This requirement however needs to be balanced against the possibility that a number of smaller reserves may have a greater diversity of habitat (Hooper, 1971) and may reduce the chance of a natural or accidental catastrophe.

If an available area has to be divided, then the reserves should be as close together as possible. Proximity increases migration rates between reserves and hence the probability of recolonisation in a reserve where the colonist has become extinct (C).

Disjunct reserves should ideally be clumped rather than grouped linearly. A linear arrangement reduces interchange between populations of terminal reserves, thereby increasing the chances of local extinctions (D).

Where there are disjunct reserves, their conservation function may be improved by connecting strips of protected habitat which permit interchange of populations with restricted habitat preferences (E). Less preferably, isolation may be reduced by the use of smaller reserves between larger ones acting as "stepping stones" for some species.

A reserve should be as nearly circular in shape as possible, to minimise edge and external effects and dispersal distances within (F).

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1. The application of island biogeography theory to conservation of the New Zealand avifauna is outlined by Fleming (1975) and is graphically illustrated by Flux (1977).

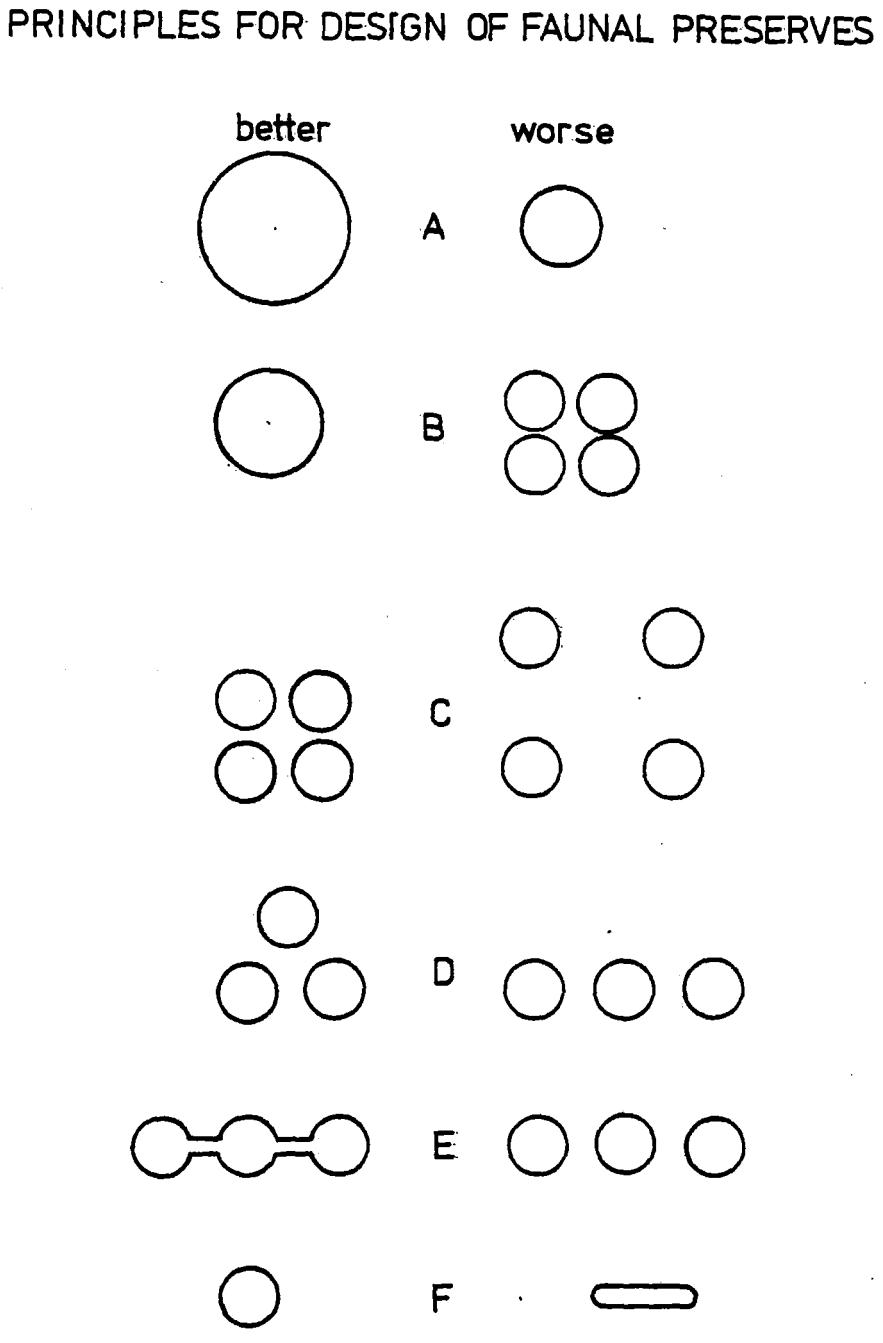

FIGURE 12: Suggested Geometric Principles, Derived from Island Biogeographic Studies, for the Design of Natural Preserves. In each of the six Cases Labelled A through F, Species Extinction Rates will be Lower for the Reserve Design on the Left than for the Reserve Design on the Right (from Diamond, 1976).

This requirement however, should be balanced against the needs of any vulnerable edge species.

(c) Population Genetics.

The following treatment draws substantially on Miller (1979).

Genetic considerations are important in the management and conservation of "island populations" in reserves where migration among reserve populations isolated from once larger genetic pools is limited or non-existent, or where genetic resources within finite reserve areas are limited by population size. Small, isolated reserve populations are susceptible to losses of genetic variability. This reduces their potential capability to adapt to changing environmental conditions and hence their chances of long-term survival and evolution.

Three processes, inbreeding, genetic drift, and the "bottleneck" and "founder" effects, are the primary factors acting to reduce genetic variability in small populations. Inbreeding, or mating between genetically related individuals, is almost inevitable in small populations, and directly causes decreased genotypic variance. Genetic drift, the change in gene frequency in successive generations resulting from the random sampling of alleles in panmictic populations, can also cause loss or fixation of alleles within a population. Its effects are most noticeable in small, genetically isolated populations where genetic variance between successive generations is greatest. The "bottleneck" and "founder" effects relate to the genetic effects arising when a population is reduced to a fraction of its former size or when a few individuals establish a new population elsewhere. In both cases only some fraction of the genetic variance of the original population is retained in the new one.

When genetic variability is reduced in small populations, differential selection will act to enhance the probability that the populations will differ genotypically and phenotypically from the parent populations. Genetic variability can only be regained through immigration or by mutation, in the latter case only over numerous generations. Thus reduced genetic diversity, and hence reduced adaptability, may become the norm in small isolated reserve populations. The characteristics and mechanisms which make species vulnerable to these effects are largely unknown, as are the different critical population sizes below which the effects become significant. Species which appear particularly vulnerable are those of high longevity, low rates of natural increase,

low mobility or other dispersal mechanisms, and naturally low population densities (often related to high trophic level position).

To mitigate adverse effects of possible genetic changes in vulnerable populations, three criteria for selection and design of reserve emerge. The first, area, has already been indicated to be important from consideration of objectives of nature conservation as well as from island biogeography theory. A reserve should be sufficiently large to support the minimum effective population size of all vulnerable species. Where this value is unknown, as will often be the case, generous estimates may need to be made.

The further criteria, provision of corridors between and provision of buffer zones around reserves, are suggested by consideration of maintenance of genetic vigour but they are also suggested from practical management considerations. Corridors of natural or semi-natural habitat linking reserves are important in maintaining gene-flow between isolated populations, and preventing deleterious genetic effects from taking hold. It has been estimated that in the absence of selection only one to a few migrants per generation, regardless of population size, will prevent differentiation between populations. Where corridors are not available the genetic integrity of vulnerable species can be maintained by artificial exchange of individuals between population centres.

Buffer zones of semi-modified habitat provide conditions suitable for continuing adaptation and evolution of species reserved in the core natural areas. Thus they are important in reducing the probability of genetic stagnation. They may also act as re-stocking sources if necessary, and protect the core natural area by filtering human influences and activities.

3.2.3 Summary of Criteria for Selection and Design of Reserves

Ten criteria have been identified which are important in the selection and design of reserves, including those intended to be representative and those intended to preserve unique features. Six of these criteria derive principally from consideration of the objectives outlined in an earlier section. One of these six, area, derives also from consideration of scientific principles in island biogeography and genetics. Another criterion derives from considerations of administration and management. The last three criteria derive principally from technical considerations in biogeography and genetics which have been the subject

of more detailed exposition in section 3.2.2. These ten criteria are outlined here in summary form.

1. Representativeness

A system of representative reserves should include samples of the full range of landforms, biota and natural phenomena within a region. Generally the selection is done on the basis of major plant communities, as these are easiest to identify and are usually closely related to landforms, soils, and animal communities. As plant communities or ecosystems vary in composition throughout their geographical range,a system of reserves is usually needed to cover all the variation. Such replicate samples should be designed to provide a satisfactory spatial system for the movement of animals, whether such movement be short term such as is involved in diurnal feeding behaviour or stormsheltering or longer term such as occurs in seasonal migration.

2. Minimum Human Disturbance (Naturalness)

A reserve should have a primeval character, relatively unmodified by human influences. However, it may be appropriate to include modified ecosystems for their value in scientific study or to protect particular natural features. In instances where an ecosystem has been wholly or mostly modified, a modified ecosystem may be the only representation possible.

3. Area

A reserve should be sufficiently large and remote to be protected from unplanned human influences, and to minimise the chance of destruction by natural or accidental forces. A large reserve is more likely to incorporate greater ecological diversity and provide for the habitat requirements of wide-ranging animals.

4. Ecological Diversity

Reserves should aim to cover the range of diversity in species, communities, habitats and ecosystems. Such diversity is often expressed in differences in local climate, topography, water regime, soils, aspect, and altitude. Reserves should also include seral communities, ecotonal communities of ecological and biogeographical significance, and a variety of animal habitats.

5. Rarity

Rare, unique or endangered species, habitats, communities and ecosystems should be included within reserves. Aggregations of rare features, such as several or many rare species occupying a plant or animal refugium, are particularly valuable. In many instances protection may not be possible within a representative reserve system, in which case unique reserves may be used. The full range of habitat should be included for rare and endangered species.

6. Ecological Gradients

Ecological gradients such as altitude, latitude, soil catenas, salinity, aspect and climatic factors are valuable within reserves, to encompass the range of variation in biota and to provide a spectrum of genetic variability.

7. Effectiveness as a Conservation Unit

A reserve should be well-defined, preferably through the use of natural features such as catchment boundaries, ridges and rivers (Bassett, 1977). It should be easily managed and protected, and should have a legal and administrative status commensurate with its importance (McAlpine and Molloy, 1978; Dingwall and Miers, 1979). Other factors being equal, foresight may secure avoidance of later destructive activity such as roading or mining.

8. Spatial Distribution

For a given area, a reserve should have minimal perimeter. If parts of the reserve must be separated from one another, the separation should be minimal.

9. Provision of Corridors

If parts of a reserve must be separated from one another, corridors of compatible use or of less modified condition should as far as possible be provided between the parts.

10. Provision of buffers

Buffer zones of less modified or of compatible use should be provided for core natural areas where this is feasible.

3.2.4 Systems of Assessment of Nature Conservation Values

In most nature conservation assessment exercises, a system using some combination of scientific criteria is used to provide an overall nature conservation value or rating. In essence, an

area or natural feature is assigned a value by each criterion, and the values are then summed in some way. An objective scoring system can be used to provide the assessment for a particular region or within a limited habitat range, but in extensive exercises where there is a complexity of ecosystems and interdependence of criteria, variable weighting of criteria or even subjective evaluation may be used.

Two different kinds of situations may be recognized. In a broad land use planning context, nature conservation values of the whole planning area are assessed. Areas of highest value are identified, and reserves chosen from the range of alternatives and in relation to the social values of other possible land uses. Examples are management zoning of New Zealand's State forests (Conway, 1977), a recent land use study of South Westland (Wilkinson and Garratt, 1977), a study of conservation of the forests of the Paparoa region in North Westland (Park and Bartle, 1978), and an outline of a system of ecological reserves for Australia (Fenner, 1975).

The other kind of situation is the assessment of discrete natural features. Examples include assessment of all remnant natural features in a highly modified landscape (Ratcliffe, 1977), assessment of tall lowland forest remnants on alluvium in the north of the South Island (Park and Walls, 1978), evaluation of British limestone pavement flora (Ward and Evans, 1976), and assessment of the reserve for the Castle Hill buttercup (McCaskill, 1979).

The choice and combination of criteria used in different situations will vary. Criteria additional to those in section 3.2.3 may also be used. Fragility, recorded history, potential value and intrinsic appeal are additional criteria used by Ratcliffe (1977) in an extensive review of nature conservation at a national level. In the selection of biosphere reserves, representativeness, diversity, naturalness, effectiveness as a conservation unit, and international significance are the five criteria used (McAlpine and Molloy, 1977).

Two nature conservation assessment exercises of relevance and illustrative value to a system for assessing the nature conservation value of forest remnants on Bell Hill Farm Settlement are outlined below.

The Scientific Co-ordinating Committee for Beech Research is an advisory scientific panel, reporting to the Minister of Forests, with responsibility for making recommendations for scientific reserves in New

Zealand State forests. It has incorporated various criteria in the following guidelines which are used to assist in defining areas for reservation (Bassett, 1977).

"(1) The reserve should represent the full range (both virgin and already modified) of land forms, vegetation and soil sequences, and animal communities of the region.

(2) It should be large, with say a minimum of 1000 ha; a single large reserve is preferable to two or more smaller reserves of the same total area. This is particularly true for preserving the greatest diversity of bird populations. It is considered legitimate to create small reserves to preserve unique features, although these could present special problems in protection.

(3) It should include at least one complete undisturbed catchment of a permanent waterway.

(4) It should have a compact shape, with the minimum perimeter for the area involved.

(5) Wherever possible, its boundaries should be clearly defined by natural features.

(6) It should be unroaded, at least within the main catchment."

Of the Committee's recommendations covering the West Coast north of Okarito, 22 ecological areas covering 80 000 ha of State forests were approved in 1979 and are in the process of being gazetted (Anon., 1979c). Two ecological areas, Deadman and Deep Creek, are in Mawhera State forest adjacent to the Bell Hill Farm Settlement.

Park and Walls (1978) developed an inventory system for identifying the regional distribution and diversity of tall forest remnants on lowland plains and terraces in Nelson and Marlborough, and assessing and ranking their conservation value. It was hoped that their pilot study would stimulate and provide a base for similar evaluations of other threatened landscapes throughout New Zealand. A semi-quantitative "Conservation Status Index" was derived to provide a simple numerical index of the comparative value of each stand. The ecological criteria used in assessing the conservation value of 932 forest stands were (in order): modification, landscape category, species rarity, size of stand, and representativeness according to forest type in biogeographic region and Land District. Stands were ranked by each criterion, and the ranking converted to a numerical scale and summed to produce the Conservation Status Index.

The nature and purpose of the present study on the Bell Hill Farm Settlement is very similar to that of Park and Walls' (1978) inventory. The methodology used in the inventory has therefore been adopted, with appropriate modification, for assessing the conservation values of the forest remnants on the Farm Settlement. The system used is described in detail in section 3.4, after the following section which places the conservation of the Farm Settlement forest remnants in a national and regional context.

3.3 NATURE CONSERVATION IN NORTH WESTLAND

3.3.1 International Significance of New Zealand Biota

Although the number of species is not high, the New Zealand biota is truly unique in the world. The flora and fauna include some species of very ancient lineage and a remarkable diversity of others which have colonised, evolved and radiated during the 80 million years since New Zealand separated from the ancient Gondwanaland super-continent.

Within the 1996 species of the vascular flora, there is a high degree of endemism[1] at the specific level, although it is much less at the generic level. Forty-one percent of the fern species and 85 percent of seed plant species are endemic. Ten percent of the indigenous plant genera are endemic (Godley, 1975 and 1976). The kauri *(Agathis australis)*, some podocarps, the southern beeches, many ferns (including the tree ferns) are relics, or living fossils, of Gondwanaland forests (Stevens, 1980).

Among the invertebrates are many species of very ancient affinities. They include *Peripatus* (Phylum Onychophora), many of the 173 species of native earthworms, some flightless ground-surface insects such as wetas *(Deinacrida, Hemideina)*, some native land molluscs *(Paryphanta, Wainuia)*, and some freshwater mussels and crayfish (Stevens, 1980). There is a general high degree of endemism at the specific and generic levels among the 9460 known species of insects in New Zealand, and specific endemism reaches 100 percent in some groups (Watt, 1975). More than 90 percent of the approximately 20 000 arthropod[2] species in New Zealand are endemic (Molloy *et al.*, 1980). Endemism is high at the specific and generic levels in the land snail fauna (Climo, 1975).

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1. Found only in this country.
2. Arthropods includes insects.

Twenty-three of the 27 presently recognised species of freshwater fishes are endemic (McDowall and Whitaker, 1975). Native amphibians are represented by an endemic genus of primitive frogs, and native mammals by two endemic species of bats (Bull and Whitaker, 1975). The short-tailed bat is the sole member of an endemic family. Within the reptiles, endemism is high at the specific and generic levels among geckos and to a lesser extent skinks (Bull and Whitaker, 1975; Hardy, 1977; Hardy and Hicks, 1980), while the endemic tuatara is a living fossil, the only survivor of the once diverse order Rhynchocephalia (Bull and Whitaker, 1975). Thirty-seven of the 65 (57 percent) native land and freshwater birds are endemic, but if sub-fossil and recently extinct species are included the degree of endemism rises to 70 percent (Bull and Whitaker, 1975). Kiwis and the now extinct moas represent very ancient endemic orders. There are three endemic families (New Zealand thrushes, wrens and wattlebirds), and at least 25 endemic genera.

The diversity of New Zealand's biota exhibits its greatest development in a few major biotopes, including the offshore islands, alpine regions, and lowland forests and grasslands. Lowland forests are the richest, most diverse, and most complex of New Zealand's ecosystems (Molloy *et al.*, 1980) and it has been represented that they contain about 95 percent of the total fauna (Kuschel, 1975; Raven, 1976). The international value of the lowland podocarp and podocarp-beech forests is emphasised by their close relationship to the ancient Gondwanaland forests (Nature Conservation Council, 1980) and by the lack of any close equivalent outside New Zealand (Sage, 1979). The international significance of conservation of New Zealand's biotopes, including forests, can hardly be over-emphasised.

3.3.2 The Natural Landscape of North Westland

Before the advent of humans, North Westland presented a predominantly forested landscape of considerable diversity and well-defined ecological patterns.

South of the beech-podocarp boundary, kahikatea characterised the alluvial plains and terraces, predominating on swampy ground but sharing dominance with matai and totara on free-draining alluvium. Tall dense rimu forests covered the low fluvioglacial outwash terraces, and a

mixed forest of podocarps and hardwoods clothed the hill country and lower mountain slopes. North of the beech-podocarp boundary, the four beech species entered into more complex associations with podocarps and hardwoods, and displaced podocarps on some sites. Red and silver beech were dominant on the alluvial flats and terraces, hard beech was common on hill country slopes, and floristically simpler silver or mountain beech forests covered the upper montane slopes to timber line.

Under the influence of the warm coastal current and of the sheltering effect of coastal mountain ranges cutting off katabatic air drainage from the Southern Alps, a coastal broadleaf forest vegetation extended along the coast as far south as about Greymouth. On the higher terraces inland were bog forests and pakihis with their characteristic vegetation. The region also supported a small assemblage of rare and endemic plants (Given and Kelly, 1976).

The remainder of the landscape consisted largely of alpine tops, with smaller areas of riverbeds, lakes and swamps. As elsewhere in New Zealand, the alpine regions of the Paparoa, Brunner, Victoria, Elliot and Hohonu Ranges, Mt Te Kinga, and subsidiary ranges of the Southern Alps supported a typically diverse alpine flora.

There is no doubt that North Westland supported a biological richness characteristic of New Zealand's major and most diverse ecosystems. Features such as the large and continuous expanse of warm lowland podocarp and podocarp-beech forests on fertile soils, and the complementary habitat relationship between lowland and montane forests for many seasonally migrating birds, were important factors contributing to the diversity in the forest avifauna (Smith, 1888) and the lowland forest endemic invertebrate fauna (Raven, 1976). The effects of past glaciations, as evident in relative paucity of rare and locally endemic plants, should however be counted in any evaluation.

3.3.3 The Changing Landscape in North Westland

North Westland today still retains much of its natural character. European settlement has had little impact on the alpine regions apart from some early sheep grazing attempts generally ended more than half a century ago, and the effects of introduced grazing and browsing wild animals. Much of the region's hill and steepland forests also remain. The major impact has been in the river valleys, low hill country and

coastal margins of the lowlands. There the effects of mining, land clearance for agriculture, and timber milling have been particularly severe, while wild animals have had variable effect. While the upland beech and podocarp-hardwood forests have remained almost unchanged, once extensive lowland[1] forest associations, particularly podocarp forests, have been very much reduced in area and replaced by a Europeanised landscape.

Following the gold rushes in the 1860's, the pioneer farmers quickly recognized that effort in farm development was best expended on the free-draining and fertile alluvial soils of the river valleys. Felling and burning of the kahikatea-matai-totara (or mixed podocarp) forests, which were confined to these soils, subsequently occurred in all the major river valleys. Only slightly less attractive to the agriculturalists were the dense kahikatea forests on the more poorly drained ground in the valley bottoms. Today only scattered remnants of mixed podocarp forest on alluvium remain in North Westland. A total of 420 ha of dense kahikatea forest is all that remains in North Westland, Buller and Inangahua (Anon., 1978).

Extensive timber milling began at the end of last century, cutting almost exclusively podocarps, at first kahikatea and then rimu. Milling initially concentrated on the river flats and on the dense high-volume rimu forests of the low fluvioglacial outwash terraces. As the quality and quantity of the remaining resource declined, the milling industry shifted to lower volume and less accessible forests, including the lowland hill country and the mixed podocarp-beech forests. The extent of logging in North Westland is such that, unless beech becomes marketable, indigenous milling will cease within 10-15 years as the entire podocarp resource is virtually exhausted. Thus by 1995 practically all otherwise unreserved forests containing podocarps, except the steep lowland and upland protection forests, will have been logged.

The effects of logging on the different forest associations have varied. Early milling on the low terraces and hill slopes was usually followed by burning to establish pastures. Most of that land is now rough farmland, or is covered by reverting fern and shrublands. Only small remnants of the dense rimu forests remain. There is still 7000 ha

1. The upper limit of lowland forest in this part of the South Island is conventionally taken as the 600 m contour.

of terrace rimu forest in North Westland State forests (Anon , 1978), but it is unlikely that more than a small proportion of this is on the low glacial outwash terraces. Forests logged later, mostly on the hill country and higher terraces, have been largely retained as cutover forests, except where exotic conversion has taken place. North of the podocarp-beech boundary the picture is somewhat brighter. Except for red and silver beech forests cleared from the river flats and mixed podocarp-beech associations cutover for their podocarps, much of the lowland forest there is still intact.

A precise breakdown of the reduction in different forest associations is unavailable, but it is unlikely that the North Westland pattern is significantly different from New Zealand or the West Coast as a whole. During the European period, native forest cover in New Zealand has been reduced from 66 percent to 22 percent. More significantly, only 15 percent of lowland forest remains (Sage, 1979). The comparative reduction in North Westland lowland forest area is certainly less, but it may be not greatly different if the extensive cutover forests are excluded from the estimated forest remaining. For the whole of the West Coast north of the Cook River, fully 58 percent of the forest below the 150 m contour has gone (Dawson and Hackwell, 1978).

In summary, the lowland forests of North Westland have suffered the brunt of European settlement. The kahikatea, kahikatea-matai-totara, and red and silver beech forests of the river valleys, plus the rimu forests of the low glacial outwash terraces, have been largely reduced to remnant status. Within 15 years, if recent trends are to continue, most remaining podocarp and podocarp-beech forests on the hill country and higher terraces will be cutover, leaving only the unmerchantable lowland protection forests and pure beech forests intact.

3.3.4 Nature Reserves in North Westland

Nature conservation requirements in North Westland are currently met by a partly complementary reserve system based on national parks, scenic reserves and ecological reserves. National parks and scenic reserves are administered by the Department of Lands and Survey, and have reasonably secure legislative and administrative protection. Ecological reserves (or dedicated ecological areas) are administered by the New

Zealand Forest Service. Their security is questioned by Molloy *et al.* (1980) as well as in many less formal appraisals.

Arthur's Pass National Park lies on the margin of the North Westland district. The Park straddles the Southern Alps and has an area of 98 385 ha, of which 26 766 ha is within Westland. The vegetation is almost exclusively hardwood-podocarp and beech forest and alpine grasslands on mountainous country.

There are 30 scenic reserves in North Westland, established over the last 80 years and now covering an area of 8870 ha (McCaskill, 1975). They were set aside chiefly for scenery preservation and catchment protection, but they also perform a valuable nature conservation function. With the exception of Mt Te Kinga (3739 ha and 42 percent of the total area), the reserves tend to be small, ranging from less than 1000 ha down to 0.6 ha (Refuge Islands on Lake Brunner). They consist largely of unlogged forest, although many contain some modified vegetation. The reserves are concentrated along the coast and in the Arnold River valley, so the range of landforms and vegetation is limited.

After much debate, the Government in 1979 approved the establishment of a system of ecological areas to be reserved in State forests on the West Coast. Twelve such reservations totalling 35 000 ha were approved in the North Westland region (N.Z. Forest Service, 1980): Porarari (6448 ha); Saxton 4120 ha); Roaring Meg (3600 ha); Lake Christabel (10 648 ha); Waipuna (1910 ha); Flagstaff (1622 ha); Lake Hochstetter (1803 ha); Deadman (240 ha); Deep Creek (603 ha); Card Creek (2870 ha); Greenstone (1144 ha); and Three Mile Hill (176 ha).

These reservations were recommended by the Scientific Co-ordinating Committee (SCC) as part of its brief to design a system of scientific reserves in New Zealand's State forests. The criteria used in defining reserve areas are cited from Bassett (1977) in section 3.2.4. Areas were selected primarily on the basis of data and forest type maps from the 1946-1955 National Forest Survey (Nicholls, 1974). Regional avifaunal survey results were only cursorily considered in reserve formulations. The areas are located throughout the State forests of North Westland. Their composition, a varied mixture of logged and unlogged forests on the higher terraces, hill country and mountain slopes, partly reflects the location pattern of the State forests above the

major river valley floors and low terraces.

Prior to the Government's approval, an Officials Committee established to consider the "social, economic and environmental impact" of the reserves proposed by the Scientific Co-ordinating Committee recommended significant excisions from three of the reserves above (Anon., 1979a). These were deleted from the reserved areas before Government approval was given. The Officials Committee also recommended a continued logging moratorium on a further 1500 ha adjacent to the Lake Hochstetter reserve, until a review of its status in 1984.

3.3.5 Adequacy of Nature Reserve System in North Westland

The focal point of any assessment of the adequacy of the nature reserve system in North Westland must be the lowland forests. Montane forests and alpine grasslands are well represented within reserve systems and are reasonably secure even if not reserved. However, lowland forests have been the most subject to past clearing and modification, and still are under pressure from the demands of competing land uses. Moreover they are of greater importance to the conservation of forest fauna and flora. The greater floristic diversity of lowland forests compared with the very simple montane forests has long been apparent. More recently, studies have shown the importance of lowland forests in terms of their richer resident avifauna, and their role as essential winter habitat for many birds living in the higher altitude forests and montane valleys (Best and Harrison, 1976; Taylor, 1977; Dawson *et al.*, 1978; Moynihan *et al.*, 1979). Forest birds are probably also good indicators of the needs of other forest animals (Dawson and Hackwell, 1978).

The general inadequacy of the nature reserve system in representing lowland forests is shown by the altitudinal analysis in Fig. 13 derived from Dawson and Hackwell (op. cit). Although the data cover all of the West Coast north of the Cook River, the pattern in North Westland is substantially the same. Of the original forest in the 0-150 m range, only about two percent is assured protection. The figure is about 3.5 percent in the 150-300 m range, and less than four percent in the 300-450 m range. Lowland forests have been substantially cleared, and much of that remaining which is outside reserves ("unprotected") is cutover. From being the most abundantly forested before European

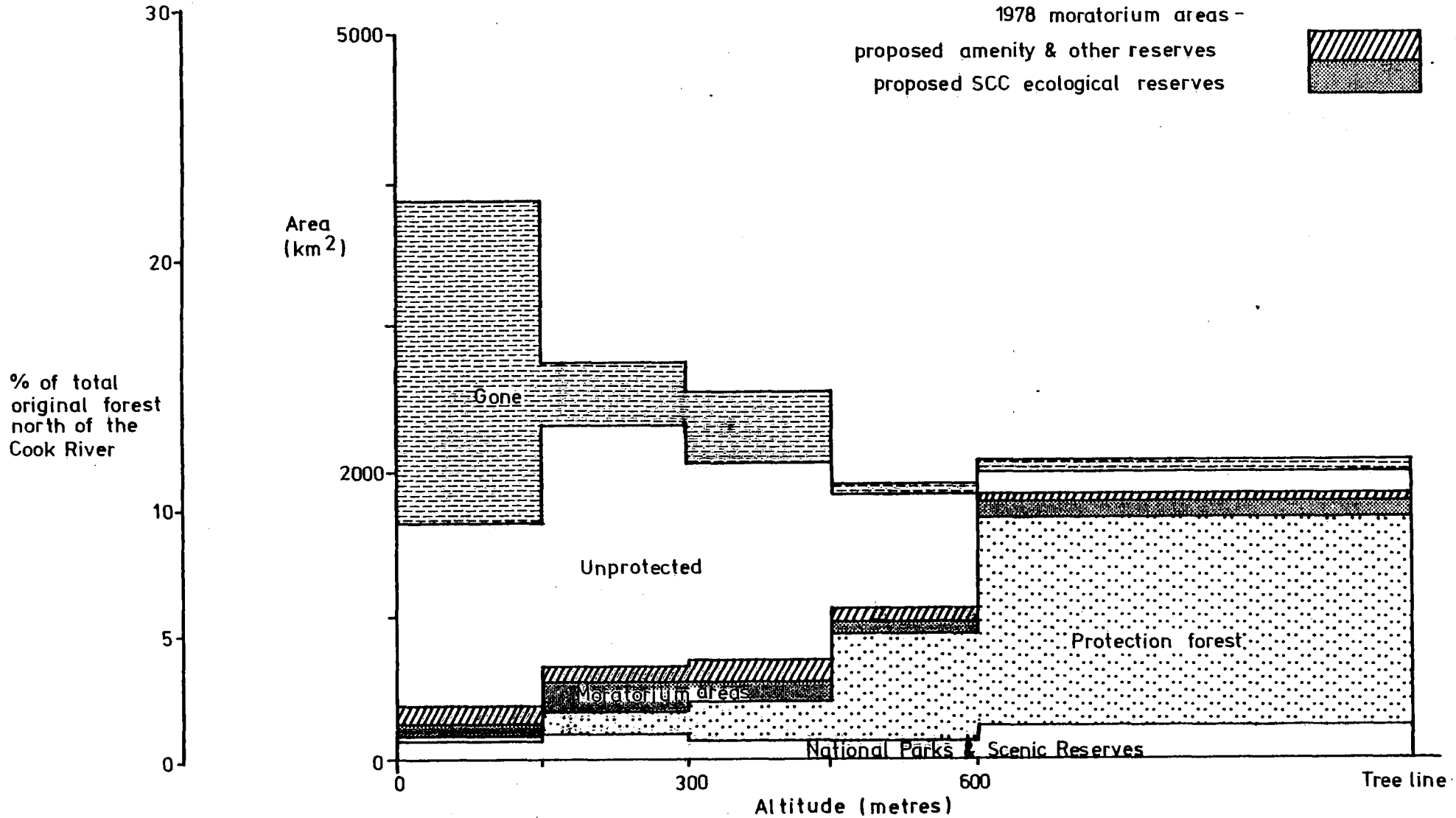

FIGURE 13: Altitudinal Distribution of Forests on the West Coast North of the Cook River, in Pre-European Times and Now. Not all 1978 Moratorium Areas were Approved for Reservation. (From Dawson and Hackwell, 1978.)

settlement the lower altitude zones now have the least areas protected.

Accordingly, representation of the forest associations of the river valleys and low glacial terraces in North Westland is the least adequate and representativeness of regional nature conservation is thereby vitiated. It has been estimated that 65 000 ha of valley floor podocarp and podocarp-beech forest has now been reduced to 12 000 ha (Grant, 1978). Some associations have suffered more than others. There is only 420 ha of dense kahikatea forest remaining in all of North Westland, Buller, and Inangahua, of which 120 ha is protected in scenic reserves and perhaps another five ha in ecological reserves (Anon, 1978). Mixed kahikatea-matai-totara forest also occurs within scenic reserves, but it too is rare. Dense rimu or rimu-kahikatea forest on low glacial outwash terraces is equally rare in the region, and is even more rare in reserves. Scenic reserves offer the main representation of the valley floor podocarp and podocarp-beech associations in North Westland, with perhaps a further 400 ha in ecological reserves (Anon., 1978). Unfortunately the scenic reserve system is limited in size and scope, and fragmented and localised in distribution. Opportunities for expansion or improvement are limited.

The other lowland forest associations on the higher terraces and hill country are to an extent still common. Because of land tenure patterns they fall largely within the scope of the State forest ecological reserve system. Despite the potential for reserves, it has been argued that the system of proposed ecological areas was emasculated in the events leading up to reservation (Anon., 1980), and that they are inadequate in fulfilling their stated purposes. The imbalance in lowland forest reservation was begun by the Scientific Co-ordinating Committee's selecting reserves to represent present forest patterns, whilst ignoring the substantial past depletion of lowland forest (Anon., 1979c). The imbalance was compounded by the Officials Committee, which selectively removed a significant proportion of podocarp forest from the proposed reserves, 80 percent of it below 300 m (Anon., 1979b). Now the bulk of the reserves is made up of protection and logged forest. There is only 9200 ha of merchantable (podocarp and red and silver beech dominant) forest in ecological reserves on all of the West Coast north of the Cook River, representing three percent of the

remaining merchantable forest and an even smaller proportion of the original forest area (Anon., 1979b).

Representation of the major biogeographical boundary in North Westland, the beech-podocarp ecotone, is likewise inadequate. The ecotone is of high scientific importance, and has been the subject of considerable study (e.g. Mew and Leamy, 1977; June, 1980). Three reserves were originally proposed by the Scientific Co-ordinating Committee to represent the ecotone, Roaring Meg, Lake Hochstetter and Deep Creek (Anon., 1979a). The Lake Hochstetter reserve was halved by the Officials Committee before reservation. Selection of the Deep Creek reserve was based on inaccurate National Forest Survey mapping, and its representation of the beech-podocarp ecotone is more apparent than real. Contrary to the description in Anon. (1979a), the only beech forest in the reserve is a narrow band of red and mountain beech fringing Deep Creek on the southern boundary of the reserve, and a small outlier of red, mountain and hard beech on the high terrace (June, 1980; personal observation). The reserve is disjunct from the main North Westland beech stands. The mistake has hitherto not been corrected despite its being drawn to the attention of the Scientific Co-ordinating Committee.

The needs of the forest avifauna, perhaps the most vulnerable element in native forest ecosystems, were practically ignored in the establishment of the ecological reserve system. Requirements for avifaunal conservation centre on large reserves, diversity and continuity of habitats, and corridors between reserves to facilitate seasonal movements and migration between reserves. It is clear that these cannot be met by the scenic reserve system. However proposals by the New Zealand Wildlife Service (Best and Harrison, 1976) to extend some of the proposed ecological reserves and link them by a network of wildlife corridors were only partly accepted by the Scientific Co-ordinating Committee, and were subsequently excluded from the Government's approval of the establishment of the ecological reserve system (Anon., 1980). Personnel of both the Wildlife Service (Imboden and Crook, 1978) and the Ecology Division of the DSIR (Dawson and Hackwell, 1978) consider the present reserve system inadequate for the long-term survival of forest birds, particularly vulnerable species such as kaka and parakeets for which

cutover and exotic forests are no substitute. Clearfelling is currently proceeding in the proposed wildlife corridor between the Lake Hochstetter and Flagstaff reserves (Anon., 1979c).

3.4 ASSESSMENT OF NATURE CONSERVATION VALUE OF FOREST REMNANTS ON BELL HILL FARM SETTLEMENT

3.4.1 Regional Significance of Forest Remnants

It has been shown (section 3.3.5) that in general the lowland forest associations of North Westland have been greatly reduced in extent and are very poorly represented in reserve systems. It is nevertheless useful to examine the extent and adequacy of the representation in reserves of the forest associations on the Farm Settlement.

The Farm Settlement lies primarily on the relatively young late Otiran glacial moraines and outwash terraces of the Moana and Loopline formations. In North Westland these formations occur in five major river valleys: the Taramakau, Arnold-Crooked, Nelson Creek, Ahaura and Grey (Bowen, 1964; Gregg, 1964; Warren, 1967). The latter three are north of the beech-podocarp boundary and the young glacial formations there are (or were) covered by beech-podocarp forests. In the Taramakau and Arnold-Crooked valleys (including the Farm Settlement), podocarp and podocarp-hardwood forest is (or was once) the principal vegetation on the young glacial formations.

Excluding reserves on or within a few kilometres of the coast and those north of the beech-podocarp boundary, there are 10 scenic reserves and no ecological areas[1] occurring on the Moana and Loopline formations in North Westland (McCaskill, 1975; Anon , 1979a). The scenic reserves include Arnold River (30 ha), Arnold River I (227.8 ha), Arnold River II (47.7 ha), Moana (59 ha), Bell Hill (78.5 ha), Lake Brunner (279 ha), Hohonu (145.3 ha), Paynes Gully (35.6 ha), Crooked River (30.3 ha) and Lady Lake (280.4 ha, of which about 200 ha is water).

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1. There is one ecological area in Hochstetter State forest (Flagstaff - 1622 ha) which lies north of the beech-podocarp boundary and which is entirely on Moana and Loopline moraine deposits. Its podocarp-beech forests are substantially logged.

Six of the reserves include representation of forests on Moana formation moraines, of which two (Arnold River and Arnold River II) have been logged and four not (Moana, Lake Brunner, Crooked River and Lady Lake). Forest on Loopline formation moraine is represented in four reserves (Paynes Gully, Arnold River I, Bell Hill and Hohonu), of which only one (Hohonu) is not logged. The Arnold River I reserve contains a small area of heavily cutover forest on Loopline outwash terrace. This is the only representation of forests on young glacial outwash terraces in North Westland reserves[1].

The forests on the minor landforms of the Farm Settlement are a little better represented in reserves. Forests on alluvium, principally unlogged kahikatea and kahikatea-matai associations, occur in the Arnold River I, Lady Lake and Crooked River scenic reserves. Small areas of forest on Tertiary sandstone and siltstone are included within the Deadman and Greenstone State forest ecological areas.

Beech or beech-podocarp forests, of various associations and on a variety of landforms, are represented in the Eldon Coates scenic reserve and Flagstaff and Hochstetter ecological areas. However the area of reserved beech-podocarp forest on young late Otiran glacial outwash terraces is small. The beech-podocarp boundary is likewise poorly represented (section 3.3.5).

It is clear that reservation patterns of the forest associations on the Farm Settlement are little different from those of lowland forests in North Westland generally. The inadequacy of the reserve system is demonstrated by the almost complete omission of forests on young late Otiran glacial outwash terraces, forests which were formerly of considerable extent in the region. Representation of forests on other landforms and of beech-podocarp forests is limited. Reserves are generally small and scattered, many have been modified by logging, and all are inadequate in meeting the requirements of the more vulnerable elements of the forest avifauna.

Although many of the forest remnants on the Farm Settlement are in a degraded condition, reservation of some of the forest associations on young glacial landforms would certainly enhance the representativeness

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1. There is an area of unlogged dense terrace rimu forest in the Lake Kaniere scenic reserve, outside the North Westland region as here defined.

of the North Westland reserve system. Incorporation of some remnants into adjacent existing reserves may have a similar effect and will significantly improve the conservation value of those reserves. The forest remnant avifauna of the Farm Settlement is significant in the North Westland context (section 2.6.3.3 (a)) and the forest remnants may also be valuable for invertebrate conservation (section 2.6.1). In short, conservation of forest remnants on the Bell Hill Farm Settlement may make a significant contribution to nature conservation in North Westland.

3.4.2 Scientific Criteria and Orders of Rank for Assessing Conservation Value

The methodology used in assessing and ranking the forest remnants according to their conservation value is modelled on that in the *Inventory of Tall Forest Stands on Lowland Plains and Terraces in Nelson and Marlborough Land Districts, New Zealand* (Park and Walls, 1978). The Inventory was a very similar exercise to the present, but on a regional scale. Appropriate modifications have been made to take account of local conditions on the Farm Settlement.

The scientific criteria selected to assess the nature conservation value of the forest remnants are: regional community representativeness, and relationship to beech-podocarp boundary; area; degree of modification; and number of forest dwelling native bird species. The number of forest bird species is an indirect but integrating measure of several other criteria, including ecological diversity, spatial distribution and corridors between reserves. Effectiveness as a conservation unit is excluded here but is considered under management in Chapter 4. Other criteria are not used as they are either outside the author's field of competence (species rarity) or are inappropriate to a local exercise (ecological gradients, buffer zones).

The criteria used, and the ranking system for each criterion, are explained below and summarised in Table 6.

TABLE 6: Scientific Criteria and Orders of Rank for Assessing Conservation Value of Forest Remnants on Bell Hill Farm Settlement

Criterion I. Regional Community Representativeness and Relationship to Beech-Podocarp Boundary

Rank

A. Communities A1, A2, A3, B1, B1v, B2, B2v
Isolated outliers of A5, B5, B6, B7

B. Communities A4, B3

C. Communities A5, B6, C1, C1v, D1, D1v

D. Communities B4, B5, C2, E1

E. Community E2

Criterion II. Area (ha)

Rank

A. 40.0^{+}

B. 20.0 - 39.9

C. 10.0 - 19.9

D. 5.0 - 9.9

E. 1.0 - 4.9

F. 0.0 - 0.9

Criterion III. Degree of Modification

Rank

A. Canopy intact; understorey intact to slightly modified

B. Canopy intact; understorey modified to eliminated

C. Canopy modified; understorey intact to slightly modified

D. Canopy modified; understorey modified to eliminated

E. Canopy eliminated; understorey modified

Criterion IV. Number of Forest Dwelling Native Bird Species

Rank

A. 11^{+}

B. 8 - 11

C. 4 - 7

D. 0 - 3

I. Regional Community Representativeness, and Relationship to Beech-Podocarp Boundary

This criterion is a measure of the extent to which forest remnants represent forest associations of the natural North Westland landscape. Highest value is given to regionally depleted or now rare associations, and to forest remnants which are significant in relation to the beech-podocarp ecotone.

The framework of the ranking system is modelled on that developed by Imboden (1978) for ranking wildlife habitat values. A "low" category is not used because the regional extent of forest depletion is such that all remnants have some value.

A. Outstanding

Matai, kahikatea-matai, and kahikatea dominant communities on alluvium (A1, A2, A3), plus kahikatea-rimu and rimu dominant communities on young glacial outwash terraces (B1, B1v, B2, B2v) are ranked as outstanding value. These communities have been reduced to remnant status in North Westland.

Isolated beech outliers are of outstanding value because of their importance to beech migration and forest ecology studies.

B. Very High

Mixed kahikatea-rimu communities on alluvium and young glacial outwash terraces (A4, B3) are given a very high value. These are now uncommon in North Westland.

C. High

A high value is accorded red beech communities on alluvium and young glacial outwash terraces not occurring in isolated outliers (A5, B6), and rimu-miro-hardwood communities on glacial and Tertiary hill country (C1, C1v, D1, D1v). Such communities have not been logged or cleared to the extent of those above, although much is still open to exploitation.

D. Medium

All remaining communities except shrublands without significant regeneration are ranked as medium value (B4, B5, C2, E1). These communities are either induced or have not been greatly subject to exploitation pressures.

E. Potential

Shrublands without significant regeneration are given a potential ranking (E2).

II. Area

The importance of area to nature conservation has been discussed in section 3.2.

The orders of rank provide some separation of the lowest size classes, which contain the majority of the forest remnants.

III. Degree of Modification

The ranking system summarised in Table 6 is similar to that of Park and Walls (1978). Intact forest remnants are ranked higher than modified ones (although modified communities may regain their natural character over a long period of time). Modification of the understorey is considered less important than modification of the canopy. Shrubland communities, in which the canopy and understorey have been severely modified or eliminated by burning, are ranked lowest.

IV. Number of Forest Dwelling Native Bird Species

The number of forest dwelling native bird species is to an extent an inherently variable measure (section 2.6.3.3). However, it is a valid criterion in itself, and is also useful as an indirect measure of other factors not explicitly incorporated within the range of criteria for nature conservation assessment used here. It is partly a function of area, but also of ecological diversity, spatial distribution and the extent of habitat corridors between forest remnants.

The number of ranks vary for the four different criteria (4, 5 or 6). To accomodate them equally, each rank is scored out of a maximum of 60, the lowest common multiple of these numbers. The scoring ranks are shown in Table 7.

TABLE 7: Scoring Ranks for Conservation Status Index (C.S.I.)

For Criteria I and III:

Score - 60 for Rank A
48 for Rank B
36 for Rank C
24 for Rank D
12 for Rank E

For Criterion II:

Score - 60 for Rank A
50 for Rank B
40 for Rank C
30 for Rank D
20 for Rank E
10 for Rank F

For Criterion IV:

Score - 60 for Rank A
45 for Rank B
30 for Rank C
15 for Rank D

3.4.3 Derivation of Conservation Status Index (C.S.I.)

The Conservation Status Index (C.S.I.) is a whole number percentage figure, and is derived in the most simple case as follows:

$$\text{C.S.I.} = \frac{X}{240} \times \frac{100}{1} \qquad (1)$$

where X = sum of scores on Criteria I, II, III and IV (maximum score = 240)

Where there is more than one community and/or degree of modification per forest remnant, each combination is summed separately on criteria I, II and III. These sums are combined to derive an overall sum score (X_T) on the three criteria using the following formulae:

for n = 2,

$$X_T = y_1 + (180 - y_1)\frac{y_2}{720} \qquad (2)$$

for n = 3,

$$X_T = y_1 + (180 - y_1)\frac{y_2}{720} + \left\{180 - \left[y_1 + (180 - y_1)\frac{y_2}{720}\right]\right\}\frac{y_3}{1620} \qquad (3)$$

where X_T = derived sum score of all combinations on Criteria I, II and III

n = number of plant community - area - modification combinations per forest remnant

y_1, y_2, y_3 = sum score of each combination on Criteria I, II and III ($y_1 \geq y_2 \geq y_3$)

The C.S.I. is then found by:

$$\text{C.S.I.} = \frac{(X_T + X_{IV})}{240} \times \frac{100}{1} \qquad (4)$$

where X_{IV} = score on Criterion IV

In effect each successive lower score combination (y_2, y_3 ...) provides an additional but rapidly decreasing value which is proportional to two factors: (a) the value of y_2, y_3 ...; and (b) the fraction of the remaining possible score on the three criteria (up to the maximum of 180). Note that the number of birds recorded (Criterion IV) is from the entire forest remnant and is therefore excluded from this procedure. The general formula used in cases of more than three combinations, the derivation of formulae (2) and (3), and some examples are outlined in Appendix 5.

Some forest remnants have no data on the number of birds (Criterion IV). In such instances the C.S.I. is calculated only on Criteria I, II and III:

$$\text{C.S.I.} = \frac{X'_T}{180} \times \frac{100}{1}$$

where X'_T = sum or derived sum of scores on Criteria I, II and III (maximum score = 180)

3.4.4 Conservation Status of Forest Remnants on Bell Hill Farm Settlement

The rankings of all remnants on the four criteria (or on Criteria I, II and III, if applicable), and their C.S.I. values are listed in the Forest Remnant Inventory Data (Appendix 7).

A listing of all forest remnants in order of decreasing C.S.I. value is contained in Appendix 6.

To provide a standard of comparison for the forest remnants on the Farm Settlement, comparable data for the present Bell Hill scenic reserve are listed below:

Area:	78.5 ha
Landforms:	Loopline morainic hill country ridges and slopes
Plant Community:	Cl : rimu, miro (Kh); kamahi, quintinia, toatoa, broadleaf, pohaka, wineberry, marbleleaf
Modification:	C, logged, wild animals
Birds:	12
Conservation Ranking:	ACCA
C.S.I.	82%

CHAPTER FOUR

INTEGRATION OF NATURE CONSERVATION AND FARM DEVELOPMENT

4.1 GUIDELINES AND GENERAL RECOMMENDATIONS FOR PROTECTION OF FOREST REMNANTS AND OTHER NATURAL FEATURES ON FARM DEVELOPMENT BLOCKS

4.1.1 Perspective

When acquired, most farm development blocks in Westland are (or were) in a derelict condition. They have a history of forest logging and burning, extensive and irregular grazing patterns and noxious weed spread. Natural features are already highly modified. Those that remain are mostly forest remnants and shrublands but may include natural or semi-natural pakihi vegetation, wetlands or other features. Some native plant and animal species may persist in the modified landscape. While these features are important for the protection of flora and fauna and as natural ecosystems for conservation and scientific purposes, they may also have other values or uses. Forest remnants and wetlands for example, may have value for water detention and soil protection, forests especially on steep slopes and in riparian zones. Forest remnants foster honey production (a widespread activity on the West Coast), scenic and landscape diversity, and provide both stock shelter and grazing.

New Zealand resource development is entrusted to a number of different agencies, each with different objectives or goals provided in its mandate. Financial authorisation for their activities are often specific for individual, single objectives. "Land development" entrusted to the Department of Lands and Survey is no exception to this general picture.

Hence the acquisition of blocks of land for farm development inevitably dictates the development of agriculture or horticulture as the dominant land use. However, where opportunities for other land uses exist, it is highly probable that the social benefits (in a broad sense) accruing from a land management regime which aims to optimise returns from a number of land uses in a complex landscape will be substantially greater than if a predominant or single purpose land development regime is adopted and other purposes completely neglected.

Returns in such functions as flora and fauna protection or maintenance of landscape diversity may be non-quantifiable in monetary terms but are nonetheless real. Given a general commitment by the Department of Lands and Survey to multiple objective land management, and information on and awareness of the wide variety of possible land use values, it should be feasible to optimise returns and manage farm development blocks in a way which reflects, at the very least, two of the primary functions of the Department - land development, and conservation of New Zealand's natural heritage.

It is within this frame of reference, and based on the experience of the present study on the Bell Hill Farm Settlement, that the following guidelines and general recommendations to protect and enhance the natural values of farm development blocks as part of the farm development process have been formulated. The guidelines are applicable to both newly acquired and partly developed blocks, although for maximum effectiveness they should be incorporated from the earliest development stages onwards.

4.1.2. Management and Planning

The protection of natural values on farm development blocks is an on-going, long-term objective, including the development period and extending far beyond the time when the Department of Lands and Survey relinquishes control. Careful thought, planning and management are therefore required. It is suggested that the key to success lies in identification of potential conservation value, the integration of conservation requirements into the management plan of each block, and its effective implementation by sympathetic departmental officers. Subsequent management and development can be expected to follow the example set in the early stages.

For maximum effectiveness such integration should occur at the earliest possible stage, when the management plan is first drawn up. Ideally a management plan should include a suitability or capability assessment of the land for each of several different possible uses, it should recognise societal values in choosing and defining the farm development objectives from among the land use options, and it should broadly specify the pattern of development and the means of implementation.

To meet this ideal a large volume of both referential and interpretive information is initially required. Information for the agricultural or horticultural development capability assessment will become readily available from within the Fields Division of the Department, whose competence in these fields is widely recognised. Such competence derives from practical experience especially in pioneering pastoral development, making use of often limited resource survey information and supplementing it with practical survey and trial and error on a limited scale. For other possible land uses or values, it would usually pay to invite inspection and reports from a range of other groups or individuals who may have an interest in or ideas on other uses. For some possible uses, such as water and soil protection or honey production, a large or specialised information input may often be unnecessary, except of course where major drainage schemes are foreseen. However where there are or may be significant conservation or scientific values at stake, it will usually be desirable to request a scientific survey with a view to identifying the natural values and ranking them in order of their conservation and scientific importance. Suitable personnel for such a request may be available from appropriate Divisions of the Department of Scientific and Industrial Research, the Wildlife Service, the Universities, or from Department of Lands and Survey Reserve Ranger or scientific staff.

In integrating farm development and nature conservation, it is strongly suggested that the management plan should:

(a) Include a prominent list identifying all natural features of value, a brief description of the nature of those values, and a separate farm block map showing the location of these features;

(b) (i) Specify and make provision for any action (e.g. fencing) necessary to protect those natural features within the development time span, having regard to conservation priorities and the availability of resources;

(ii) Specify any constraints necessary for the protection of natural features (e.g. not draining wetlands underlain by scientifically valuable peat deposits);

(c) Incorporate as far as possible the guidelines and general recommendations on farm development and operations in section 4.1.3 herein; and

(d) Make provision for the continued protection of natural features after farm settlement, either by surveying and exempting them from alienation or by establishing appropriate covenants.

The information for (a) and (b) above should be readily available from the scientific survey report (as in section 4.2 of this report). That for (d) will reflect the nature of the values and the legislative and other provisions available (see section 4.1.4). The management plan should always retain flexibility, for given the diversity of the natural (and cultural) world it is unlikely that all features of value will be identified at the early development stage. Flexibility is advantageous for instance when additional adjoining land is purchased and opportunities arise to add to existing protected forest remnants.

The inclusion of the above in the management plan is important if present initiatives are to be continued and success utlimately achieved. Changes in Fields Division personnel are to be expected, so the management plan may be the only link of continuity to ensure new staff and farm managers can carry on from where their predecessors left off.

The initiative and resources required for the effective integration of a nature conservation programme with farm development are clearly within the capabilities of the Department. It is pleasing to note that the positive approach outlined above is being applied to the recently acquired Butler Farm Settlement south of Hokitika, and via the present report to the Bell Hill Farm Settlement. At Bell Hill, development has progressed for more than 20 years, more or less on an experimental basis and without the benefit of any multiple use capability assessment. Nevertheless past management has generally recognised other values and retained options, although some natural values have inevitably been reduced through lack of information. It is hoped that the present study will fill the information gap and aid in the achievement of a balanced farm development programme.

RECOMMENDATIONS

1. THAT A SCIENTIFIC SURVEY BE REQUESTED IN THE EARLY PLANNING STAGES OF FARM DEVELOPMENT BLOCKS, TO IDENTIFY AND RANK NATURAL FEATURES OF CONSERVATION AND SCIENTIFIC VALUE.
2. THAT FARM DEVELOPMENT AND NATURE CONSERVATION REQUIREMENTS BE INTEGRATED IN THE MANAGEMENT PLAN FOR EACH BLOCK AS EARLY AS POSSIBLE.

4.1.3 Impacts of Farm Development and Operations on Forest Remnants and other Natural Features

It is useful to examine the possible impacts of farm development and operations on the forest remnants and other natural features of farm development blocks. The integration of farm development with a positive programme of nature conservation requires that the impacts of farm development and operations on natural features, and *vice versa*, be clearly understood by all involved.

4.1.3.1 Clearance of Forest Remnants and Shrublands. In as far as it is applicable, it is the present practice of the Department of Lands and Survey to apply the principles of the Indigenous Forest Policy of the New Zealand Forest Service to unalienated Crown Land and Crown leasehold (Department of Lands and Survey, 1980).

That policy states in part:

"The need to clear (indigenous forest) should be considered as evident only when other land in the region already devoid of indigenous forest is either unavailable or unsuitable for further development to meet the Government's social and economic goals regionally and nationally. Indigenous forest should only be cleared after a study of the social, environmental, and economic factors has demonstrated that national and regional welfare would be enhanced by doing so and subject to an opportunity for the public to examine and if necessary object to the proposal" (Conway, 1977, p.8).

Hence it is encumbent on the Department to retain forest remnants on farm development blocks except where there is a clearly evident need to clear them. If the need to clear does arise, a riparian strip of forest vegetation (even second growth) should be retained along all waterways to minimise disturbance to aquatic values (McDowall, 1977).

The Indigenous Forest Policy as defined does not cover shrubland communities dominated by species such as manuka, kanuka and *Coprosma* spp.[1] recolonising the land after burning of the former forest. Past practice on farm development blocks has been to clear many of these by crushing and burning, and convert to pasture.

It is recognised that such shrublands are of widespread extent in Westland and that their retention on farm development blocks may be a hindrance to farm development. However from experience on the Bell

1. Gorse shrublands are excluded here as gorse is regarded as a "noxious" weed (but see section 4.1.3.6).

Hill Farm Settlement it is considered that the present blanket clearance policy should be modified and a more discriminatory approach adopted. Shrublands may have considerable natural value. They:

- are a seral community, representing a stage in the succession back to high forest;
- add to the diversity of habitats, and hence of flora and fauna;
- are the habitat of a number of uncommon species, including orchids, plant parasites[1] and the South Island fernbird;
- provide a natural marginal buffer to many forest remnants, reducing stock infiltration, exposure to wind, and, incidentally, reducing fencing maintenance costs (by lowering the chances of windthrown trees falling on fences).

Hence, some shrublands should be retained, even though their seral nature is such that they will be replaced by regenerating forest within 50-100 years. The present extent of shrublands in Westland is such that any positive management input to retard successional processes is not justified, but this situation may be quite different within a century. Even if shrublands are not culturally maintained, the value of the additional successional or even climax forest community will compensate to some extent for the displaced shrublands. In the absence of detailed evaluation of individual shrublands, it is considered on the basis of reserve design (section 3.2) that those shrublands associated with forest remnants (for example, those surrounding forest remnants or forming "bridges" between them) should be given priority, particularly where the forest remnant is likely to be protected.

Consideration could also be given to letting shrublands on steep south-facing slopes regenerate into forest in preference to converting to low production pasture.

RECOMMENDATIONS

3. THAT, IN ACCORD WITH THE INDIGENOUS FOREST POLICY, NO INDIGENOUS FOREST BE CLEARED UNLESS A CLEAR NEED HAS BEEN DEMONSTRATED.
4. THAT WHERE CLEARING IS UNDERTAKEN, A RIPARIAN FOREST MARGIN BE RETAINED ALONG ALL WATERWAYS.
5. THAT SOME SHRUBLANDS BE RETAINED, PARTICULARLY THOSE ASSOCIATED WITH PROTECTED FOREST REMNANTS.

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1. Orchids and plant parasites were not searched for on the Bell Hill Farm Settlement. Some are likely to be present.

4.1.3.2 Burning. Historically fire has been the principal agent of forest destruction on the Bell Hill Farm Settlement and elsewhere in Westland. There is evidence of more recent large scale fires in the north part of Weka block, but it appears that fire is now used as a management clearance tool only following crushing of shrublands.

If it is necessary to clear any forest remnants or shrublands (but see section 4.1.3.1), there are two potential impacts on natural values to be considered. The first, the danger of fire spreading beyond the intended target area into other remnants, is obvious. Such danger may be acute during some summer dry spells.

The second is the possible impact on the South Island fernbird, a relatively uncommon endemic species (see section 2.6.3.3(b)). Fernbirds may be present in any substantial area of pakihi or shrubland in Westland. The rough undeveloped farmland on many farm development blocks probably contains a sizeable proportion of the total Westland population, which is itself the last major stronghold of the South Island subspecies. Fernbirds are rather secretive birds but their presence can usually be detected without difficulty by an observer familiar with the bird's call. Because fernbirds have a poor reproductive and dispersal capacity (Spurr, 1979b), are poor fliers, and are territorial especially during the breeding season, populations are particularly vulnerable to large-scale burn-offs of shrublands and pakihis, either directly through incineration or indirectly through subsequent loss of habitat.

To date little consideration has been given to the welfare of fernbirds on farm development blocks on the West Coast (Owen, 1980). Although the higher pakihis in state forests constitute the ideal habitat, populations on farm development blocks are important to a regional fernbird conservation programme. While conversion of pakihi habitat to pasture will inevitably cause some loss of fernbird population, there are two specific measures available to help ensure the long-term perpetuation of the species. The first is to set aside from development suitable habitats with concentrations of fernbirds, as part of a programme to establish a regional system of fernbird reserves. Owen (1980) suggests such a reserve should have a minimum of 15-20 fernbird pairs, and would require about 20 ha of optimum habitat. The second is to reduce the impact of some farm management operations, particularly land clearance and burning-off. The impact

of burn-offs can be reduced by controlling their size and timing. Fernbirds have an extended breeding and moulting season during which they are vulnerable to burning (late July to early April), but the impact is probably least if burning is confined to early autumn (March-April) when moulting has finished and fernbirds have had at least a first clutch (Owen, 1980). Fires should be relatively small, certainly less than 0.5 km in width, and ring-burning should not be used (Douglas, 1979). Where warranted, fernbirds could be transferred prior to burning or clearing to suitable unoccupied habitat elsewhere.

RECOMMENDATIONS

6. THAT CARE BE TAKEN TO ENSURE ANY NECESSARY BURN-OFFS ARE STRICTLY CONFINED TO THE TARGET AREA.
7. THAT WHERE LARGE-SCALE BURN-OFFS OR CLEARANCE OF SHRUBLANDS ARE CONTEMPLATED, A CHECK BE MADE BY A WILDLIFE OFFICER OR OTHER QUALIFIED PERSON(S) FOR THE PRESENCE OF FERNBIRDS. WHERE FERNBIRDS ARE PRESENT, BURN-OFFS SHOULD BE IN EARLY AUTUMN ONLY (MARCH-APRIL), THEY SHOULD BE SMALL (LESS THAN 0.5 KM IN WIDTH) AND THEY SHOULD BE ON ONE FRONT ONLY. WHERE WARRANTED, FERNBIRDS COULD BE TRANSFERRED BEFOREHAND TO SUITABLE UNOCCUPIED HABITAT ELSEWHERE.

4.1.3.3 Roading and Farm Tracks. When acquired, farm development blocks usually have an established pattern of roads and farm tracks. However, further roading and farm tracks are often needed to meet development objectives.

The effects of roading and tracks on natural features relate primarily to their siting and construction. Usually, siting will be determined by factors such as distance, spatial pattern and topography, and constraints such as legal road lines. However, where there is any flexibility, consideration should be given to minimising damage to natural features, particularly by avoiding substantial or valuable forest remnants.

Where a road (or track) must be constructed through forest vegetation, its scenic attractiveness should be retained by clearing as little forest on both sides of the road as possible. A cleared strip of forest on both sides of a new road appears to be the current norm in Westland, supposedly to minimise problems of winter ice and of trees falling on roads. However this argument may have been overstated (Nature Conservation Council, 1979). Certainly there are no problems apparent,

for instance, in the Bell Hill scenic reserve. While in a strict sense roads constructed on adjacent legal roads are outside its jurisdiction, the Department of Lands and Survey should liaise with the roading authorities (Ministry of Works and Development and local counties) to ensure that new roads are built in a manner which retains the scenic appeal of adjacent forest or other natural vegetation on farm development blocks.

There are two instances on the Bell Hill Farm Settlement which illustrate recent lost opportunities.

In the first, the new Deep Creek road bisects an attractive stand of dense young rimu (remnants w32 and w 38). Unfortunately a wide strip on both sides of the road was cleared, spoil was heaped onto the forest edge, and drains were dug into the forest (causing some tree mortality). The second instance is the recent road extension along the northern edge of Ruru block. This follows a legal road, between the highest ranked forest remnant on the Farm Settlement (r2) and the Deep Creek ecological area in Mawhera State forest. Again a wide strip of forest was cleared, a side-track was cut through the forest on the Farm Settlement, and much of the potential scenic value was lost.

RECOMMENDATIONS

8. THAT ROADS AND FARM TRACKS AVOID NATURAL FEATURES OF VALUE WHERE POSSIBLE.
9. WHERE A ROAD MUST BE CONSTRUCTED THROUGH FOREST VEGETATION, ITS SCENIC APPEAL SHOULD BE DEVELOPED BY RETAINING FOREST VEGETATION TO THE ROAD EDGE.

4.1.3.4 Fencing. Fencing is a basic management tool for the intensive development programmes used on farm development blocks. Close fencing is vital for the management of stock and pastures[1].

Fences and fencing may have either beneficial or detrimental effects on forest remnants and shrublands. On the one hand, fencing is essential

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1. In addition, where bovine tuberculosis is present in possum populations, fencing forest remnants may be an important step in reducing the incidence of the disease in farm stock (Cook, 1975). Fencing encourages regeneration of the forest understorey, thereby reducing possum habitat quality and hence possum numbers. Fencing also helps to break the possum - cattle cycle of infection (although alternative sources of winter feed will be required to replace the common West Coast practice of grazing cattle in the bush during winter months).

for the long-term survival of forest vegetation (section 4.1.3.5). On the other, fences which cut through forest remnants represent an intrusion on their physical integrity and detract from their natural value. Past fencing on the Bell Hill Farm Settlement has had a mixed impact. Recently it has been the practice to fence off the largest forest remnants (both to protect them and to improve stock control), and most of these are now completely fenced off. On the other hand, many smaller remnants are bisected by fences and, in some cases, by a wide swath of forest cleared on each side. There are also instances where small parts of forest remnants were excluded when the main part was fenced off.

Undoubtedly there are good reasons for putting fences through forest remnants, including the need to fence farm boundaries or follow topographical features, and the desirability of straight-line fences in reducing fencing costs. However there are also good reasons for avoiding them whenever possible. Such fences subdivide forest remnants, contribute to the attrition of forest extent, and make it very difficult to plan for the protection of such remnants because of the greatly increased additional fencing required. Fences through forest remnants are also undesirable from a farm management point of view, as they have high maintenance costs consequent upon windthrow following forest disturbance. They can also contribute to difficulties in mustering of stock.

New fencing currently costs about $3 per metre, or $3 000 per kilometre (Turner, 1980). The cost of uplifting and shifting a fence is likely to be of a similar magnitude. Clearly, to keep costs to a minimum it is necessary, through *early* and careful planning of the fencing patterns on farm development blocks, to integrate the fencing requirements of farm development and nature conservation as far as possible.

The management plan should provide for fencing of all valuable forest remnants (and other natural features if required) as part of the overall fencing programme. For lower priority remnants, any fences in the vicinity should be arranged where possible to skirt around or be tangential to them, rather than missing them or cutting straight through. In these ways the *extra* cost of fencing forest remnants and other natural features can be minimised, as up to one-half or more of the additional fencing required is then a normal development cost.

Where fences are erected on farm development block boundaries, the boundary line should be surveyed first. The value of engaging surveyors is obvious where the adjacent land is freehold but it is also important for other land uses such as scenic reserves. A case in point on the Bell Hill Farm Settlement is the new fence between the recently acquired part of Blairs block and the Arnold River scenic reserve. The fence was erected without the boundary being surveyed, and has infringed in several places on the scenic reserve. The fenceline generally follows the forest edge, thereby excluding a small area of forest and considerable area of shrubland (principally gorse) from the reserve. In the context of possible transfers of forest from the farm settlement to the scenic reserve, this instance may be regarded as a rationalisation of land use rather than a serious transgression, but the practice is not one to be encouraged.

Care should be taken when erecting fences along the edges of forest remnants. Where a path needs to be cleared for the fencing contractor's machinery, that path should be cleared only on the open side of the fenceline and not, as is currently the practice, on both sides. Usually what is cleared is the valuable shrub margin of a forest remnant.

Care should also be taken to ensure that fences around forest remnants are maintained in stock-proof condition.

RECOMMENDATIONS

10. THAT FENCING PATTERNS ON FARM DEVELOPMENT BLOCKS BE DESIGNED IN THE EARLY DEVELOPMENT STAGES, WITH REGARD TO THE REQUIREMENTS OF BOTH FARM DEVELOPMENT AND NATURE CONSERVATION.
11. THAT FENCES BE LOCATED, ERECTED AND MAINTAINED IN WAYS TO PROTECT FOREST REMNANTS AND OTHER NATURAL FEATURES AS FAR AS POSSIBLE.

4.1.3.5 Stock Grazing. Where forest remnants and shrublands are not protected from stock they are inevitably grazed. Grazing by cattle is usually more destructive. Whereas sheep mostly confine themselves to the forest periphery (unless the understorey is already severely depleted), cattle graze throughout forest remnants regardless of size and browse more or less indiscriminately.

Although the grazing value of a forest understorey compares poorly with open pastures, forest remnants may be useful to stock management. Paddocks containing remnants are valuable for shelter of stock during poor weather or periods of stock vulnerability such as shearing and lambing. Small forest areas are of greatest value, as mustering stock in large areas is both difficult and time-consuming.

The effects of grazing on the forest remnants of the Bell Hill Farm Settlement have varied. Grazing has been very light in a few fairly inaccessible places and its effects are barely noticeable there. However, in general the understorey has been considerably modified, to the extent that in some remnants it has been virtually eliminated and only churned-up organic soil and exposed tree roots are left. The greatest depletion in forest understoreys appears to be in those parts of the farm that have been developed the longest.

Given the high stocking rates used during farm development, it is clear that practically all forest remnants will eventually suffer extensive damage unless protective measures are taken. Such damage may improve habitat for possums but it greatly reduces the value of the forest habitat for birds and other native animals and may cause the local extinction of many forest understorey plant and soil-animal species. In the long-term the forest canopy structure will gradually disintegrate as recruitment fails to replace mortality. Continued grazing could cause the nearly complete destruction of all forest vegetation on the Farm Settlement (and other farm development blocks) within a period of 100-300 years. Although natural features such as steep slopes or dense marginal shrubbery may offer some protection, the only guaranteed method of protection (and restoration) of remnants is fencing.

When forest remnants and shrublands on the Bell Hill Farm Settlement are differentiated according to size (see Fig.10), there does not appear to be any great conflict with respect to grazing between the priorities of farm development and nature conservation. The larger remnants, which include most with a high conservation value, are more of a nuisance value to stock management. Given a commitment by the Department of Lands and Survey to retain them, they are best fenced off to the satisfaction of both purposes. Of the numerous smaller remnants only a limited number have specific conservation values which warrant fencing, leaving the remainder open for farm management purposes. However, on other farm development blocks with a more limited range of

forest remnant sizes there may not be this degree of flexibility.

If it is desired to maintain a semblance of the present landscape into the long-term future, consideration should be given to fencing off all forest remnants of a size of any consequence. Such a programme will certainly extend far beyond the farm development period, so settling farmers should be made aware of the importance of fencing to forest vegetation and encouraged to continue a fencing-off programme.

RECOMMENDATIONS

12. THAT ALL FOREST REMNANTS OF CONSERVATION VALUE AND AS MANY OF THE LARGER REMNANTS AS POSSIBLE BE PROTECTED FROM GRAZING BY FENCING-OFF, AS PART OF THE FARM DEVELOPMENT PROGRAMME.
13. THAT SETTLING FARMERS BE ENCOURAGED TO CONTINUE A FENCING-OFF PROGRAMME.

4.1.3.6 Chemical Spraying. Chemical spraying is an indispensable farm management tool for the control of noxious weeds. While the environmental hazards of some chemicals is currently the subject of public debate the general use of chemicals may be expected to continue.

Gorse is a particular problem in Westland. Control is most commonly achieved through the use of tordon or other similar herbicides. Where there is a large infestation, the spray may be applied by air. Otherwise it is applied by an individual operator or from a vehicle.

Many native tree and plant species are susceptible to chemical sprays, some more so than gorse. The active chemicals appear to act mostly through leaf absorption, so that it is often only the canopy and other exposed foliage which is immediately killed. Mortality appears to be much higher where ground spraying is used and chemicals are absorbed through the roots.

The effects of spraying were particularly evident in the winter of 1980 on the recently acquired south-east part of Blairs block, following extensive aerial spraying of gorse. While effective in killing the gorse (and clovers), spray drift also caused considerable mortality on the periphery of forest remnants (including part of the Arnold River I scenic reserve). In one small remnant (b27) surrounded by gorse and itself almost totally sprayed, few trees escaped canopy foliage die-off.

Kahikatea appeared particularly susceptible, but other species such as quintinia, kamahi and rimu were only slightly less affected. Some die-off occurred in miro and toatoa foliage. Elsewhere cedar and red and mountain beech were also affected. Few species appeared to be unaffected, among them broadleaf and lancewood *(Pseudopanax crassifolium)*.

It is considered that a more discriminatory approach to controlling gorse in and around forest remnants and shrublands should be adopted, in preference to the current blanket spraying policy. Such gorse has traditionally been viewed as a potential seed source for reinfestation of surrounding pastures, but recent research is showing this view to be misleadingly simplistic (Hackwell, 1980a).

Gorse seed may be spread up to several metres from the parent plant by exploding dry pods. Apart from such margin effects gorse within fenced-off forest and shrubland areas is unlikely to contribute significantly to pasture reinfestation. In fact gorse seed is extremely persistent within the soil and most reinfestation is probably a consequence of the gorse that was formerly present on many grasslands. Such gorse regeneration can be controlled by effective pasture development and grazing management, which should also have the effect of controlling any localised regeneration arising from nearby gorse within fenced-off areas.

Gorse within forest remnants and shrublands is likely to disappear within a decade or two as it is replaced through natural successional processes by regenerating native forest species, provided these are uninterrupted by burning or grazing. Gorse is a nitrogen-fixing legume and has outstanding potential as a "nurse crop" in assisting native forest regeneration[1] (Hackwell, 1980b). Spraying only retards this process. It causes mortality of nearby native trees and shrubs and inhibits regeneration, thereby ensuring that even more gorse will grow back on the site.

While chemical spraying continues to be used on a large scale as a farm management tool, some effect on natural vegetation is practically inevitable. However, such effects can be reduced if there is an awareness of the values at stake. Gorse left within or on the edges of forest

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1. Gorse also has another generally unrecognised value, being an important source of early spring pollen for bees (Hackwell, 1980b).

remnants will eventually be replaced by regenerating native forest. It should not be sprayed unless it is acting as a seed source for re-infestation of pastures that cannot be economically controlled by other means.

RECOMMENDATIONS

14. THAT EVERY EFFORT BE MADE TO MINIMISE SPRAY DRIFT ONTO FOREST REMNANTS OR OTHER NATURAL VEGETATION.
15. THAT GORSE WITHIN OR ON THE EDGES OF FOREST REMNANTS AND SHRUBLANDS BE NOT SPRAYED.

4.1.3.7 Drainage. Drainage is a vital factor in the development of the wet pakihi soils which form a major part of the farm development blocks in Westland. Because of the impermeable nature of the sub-soil and the very limited lateral movement of water within it, an extensive system of deep arterial drains and numerous radiating smaller drains may often be required for effective drainage.

Damage to the physical integrity of forest remnants and shrublands, and long-term soil moisture regime and associated vegetation changes are the two main effects of such drainage programmes. Where a drain is cut through forest, some vegetation is inevitably damaged, the entry of weeds and animals is facilitated, and if ponding occurs there may be subsequent mortality of nearby trees. Long-term soil moisture changes resulting from more rapid water run-off may induce shifts in vegetation species composition away from the more hygrophilic plants. However, this effect is likely to be localised to the immediate vicinity of drains.

If contours are to control strictly the alignment of drains, it is probably inevitable that some drains will need to be cut through forest remnants. However, siting of drains should be planned, preferably at the early development stage, to avoid remnants wherever that is feasible. Where not, the width of forest cleared should be kept to a minimum and drains dug in such a way that ponding is avoided.

Wetlands of various kinds and sizes (for example, tarns, marshes and swamps) may be present on some farm development blocks. Many of these may have high conservation or scientific values, such as peat

columns, rare plants or endangered wildlife, which are not readily apparent to the casual observer. Expert advice should be obtained before any of these are drained. Drainage schemes are often found to require further development as land development itself proceeds. Sometimes channel size and grade of original drains become unsuitable for further development, with adverse consequences to hydraulic behaviour. Long-term drainage design is essential to avoid such problems.

RECOMMENDATIONS

16. THAT DRAINS BE SITED OUTSIDE FOREST REMNANTS AND OTHER NATURAL FEATURES WHEREVER FEASIBLE.
17. THAT, WHERE DRAINS THROUGH REMNANTS ARE UNAVOIDABLE, THE WIDTH OF FOREST CLEARED BE KEPT TO A MINIMUM AND ANY PONDING AVOIDED.
18. THAT EXPERT ADVICE BE SOUGHT BEFORE ANY WETLANDS ARE DRAINED.

4.1.3.8 Topdressing and Oversowing. Topdressing and oversowing likewise are indispensable management tools on farm development blocks. Aerial application of fertilisers and seed is the only practical way of establishing pastures on the scale and type of land typically under development.

Where forest remnants are repeatedly topdressed, the increasing soil fertility is likely in the medium and long-term future to induce a shift in the vegetation species composition towards plants usually occurring on naturally more fertile soils.[1] If topdressing ceases, the effect on soil fertility is likely to be fairly rapidly reversed but that on vegetation less so. Oversowing with pasture seeds is unlikely to have any effect on remnants with canopy and ground layers in good condition, but introduced grasses and other species do become established if there is sufficient light and bare ground on the forest floor.

It seems inevitable that small forest remnants and the edges of larger ones will be covered in these aerial operations. However no farm manager wants to waste expensive fertiliser and seed, so there is a strong incentive to ensure that the amount applied to forest vegetation is kept to a minimum.

1. Topdressing of native forest with phosphatic fertilisers may have scientific value, especially if designed to assess the influence of phosphorus regimes on colonisation and regeneration (cf. O'Connor, (1980). Such a value would require careful control and long-term monitoring and is not likely to derive from carelessness or accidents.

RECOMMENDATION

19. THAT, WHEN TOPDRESSING AND OVERSOWING, THE AREA OF FOREST VEGETATION COVERED BE KEPT TO A MINIMUM.

4.1.3.9 Possum Control and its Effects on Avifauna. The possum is potentially a serious pest on any farm development block in Westland which still has native forest remnants on it or in the vicinity. Its two main impacts are related to its browsing on the natural forest vegetation (particularly the more palatable species), and its implicated role as a carrier of bovine tuberculosis in cattle herds while feeding on pastures (Stockdale, 1975).

Both effects were evident on the Bell Hill Farm Settlement during 1979-1980, where possums were seen both during daylight hours and at night. Vegetation damage was evident, particularly in the higher quality forest remnants, but not extensive. Bovine tuberculosis was present on Blairs block, and a major operation had to be mounted there to reduce possum numbers.

Traditional possum control methods have centred on the private commercial operator using traps and/or cyanide baits. However commercial harvesting has generally had only a limited effectiveness in reducing possum populations (Batchelor, 1978). Where special values are involved, such as protection of cattle from tuberculosis, it is necessary to mount more intensive control operations, including prolonged trapping and aerial application of sodium monofluoroacetate (Compound 1080) impregnated carrot or other baits. Clearing of forest remnants within pastures to eliminate possum habitat may be considered in extreme cases, although no firm proposals are known to have been made[1].

All methods of possum control have hazards for non-target species. Birds are particularly susceptible. Many ground-dwelling birds, particularly kiwis and wekas, are maimed or killed every year by trapping and cyanide poisoning. Past aerial applications of 1080 carrot baits have resulted in mortality of sheep and dogs as well as birds, and possibly insects and other invertebrates (Batchelor, 1978; Harrison, 1978; Spurr, 1979b).

1. The effectiveness of any such action and its relative costs and benefits to other values should be carefully examined before it is implemented. The possum is a fairly mobile animal in forest and pasture (Cook, 1975), and large-scale forest clearance would be required to effectively eliminate possums from farms. More practical bovine tuberculosis control methods may require fencing off forest remnants (see section 4.1.3.4) and possum control through trapping and poisoning.

Little is known of the risks to many species but most forest birds should be regarded as being at risk, either directly from feeding on poisoned baits or secondarily from feeding on poisoned prey (Spurr, 1979b). It may take many years for some native bird populations to recover from reductions imposed by 1080 poisoning.

A combined trapping and subsequent aerial 1080 poisoning operation was carried out in 1979 on Blairs block and the adjacent part of Mawhera State forest by the West Coast Counties Pest Board and the New Zealand Forest Service, to reduce possum numbers and eradicate bovine tuberculosis. Despite plans to monitor these operations, they were in fact not monitored by the Animal Research Section of the Forest Research Institute, Christchurch (Spurr, 1980). Little is therefore known of any effects on the avifauna. Many dead wekas were seen by the author in the vicinity of traps laid by Pest Board operators on the Farm Settlement.

The harmful impact of possum control measures on bird populations is now generally recognised, and measures to reduce it can and have been taken. From April 1980 new permits issued by the New Zealand Forest Service for possum hunting specify that cyanide baits may not be laid on the forest floor, and baits may not be bigger than a pea (7 mm) in diameter. Wherever possible traps should be set on lean-to logs. If set on the forest floor, traps should be fenced with vegetation or rocks to prevent entry by ground birds. They must be cleared every 24 hours, as soon as possible after daylight. Forest Service, Wildlife Service and Department of Lands and Survey Rangers, and Pest Board operators are responsible for policing the new regulations. Further advice is obtainable from them, and they should be contacted if the regulations are breached.

Aerial application of 1080 impregnated carrot baits is carried out under the direction and responsibility of the New Zealand Forest Service. Operational practice was modified several years ago following extensive bird mortalities. Current practice is to use green-dyed carrot bait which has been screened to eliminate "chaff" (pieces less than 16 mm diameter). Indications are that some birds are still being killed but that the number generally does not have a significant effect on populations (Spurr, 1979a).

Possum control on farm development blocks is to be encouraged, even where an economic incentive in the form of bovine tuberculosis

is absent. The Department of Lands and Survey should encourage private operators to control possum numbers and hence reduce their effects on natural vegetation. Forest remnant blocks should be made readily available and their availability made known. Permits to trap or poison on farm development blocks should have the same conditions attached as those on Forest Service permits (see above). Where possible farm managers should ensure that permit conditions are adhered to. They may also be able to offer advice on the presence or absence of kiwis and wekas, so that precautions can be taken against accidental trapping or poisoning.

More intensive operations to reduce possum populations may be necessary where bovine tuberculosis is present or, conceivably, if valuable natural vegetation is being damaged. In Westland options include intensive trapping by the West Coast Counties Pest Board and/or aerial 1080 carrot bait application by the Forest Service. Appropriate personnel of the Wildlife Service or of the Animal Research Section of the Forest Research Institute should be consulted on possible impacts on birdlife before any operation, and the operation should be monitored if considered necessary. The precautions with regard to trapping and poisoning outlined above should be adhered to.

RECOMMENDATIONS

20. THAT THE DEPARTMENT OF LANDS AND SURVEY ENCOURAGE PRIVATE POSSUM OPERATORS TO WORK ON FARM DEVELOPMENT BLOCKS, AND THAT WHERE POSSIBLE IT ENSURES OPERATORS ADHERE TO PERMIT CONDITIONS FOR PROTECTION OF GROUND-DWELLING BIRDS.
21. THAT WHERE MORE INTENSIVE POSSUM CONTROL OPERATIONS ARE REQUIRED, THE WILDLIFE SERVICE OR THE FOREST RESEARCH INSTITUTE BE CONSULTED ON THE POSSIBLE IMPACTS ON BIRDLIFE, AND THE OPERATION BE MONITORED IF NECESSARY.

4.1.4. Status and Management of Forest Remnants and other Natural Features after Settlement

The following discussion assumes that farm settlement is viable and will proceed as currently envisaged, that existing relevant statutory legal provisions are continued, and that all work required for protection of forest remnants and other natural features is carried out during the farm development time span. Future status and management may need to be re-evaluated if any of these factors are significantly altered.

While farm development blocks are still controlled by the Department of Lands and Survey, the protection of forest remnants and other natural features is relatively simple. However, circumstances change greatly when the land is about to be subdivided and settled by individual farmers, and management control suddenly becomes diffuse. Planning for continued protection after the changeover should be within the scope of the block management plans. It primarily involves consideration of the future status and management of forest remnants and other natural features.

In general it is considered that wherever statutory protection is appropriate, it is preferable to any other status. While the growing awareness of conservation needs among sectors of the farming community in New Zealand is acknowledged, it would appear sensible not to burden newly settled farmers any more than necessary. Moreover, these natural features are a public asset and they should remain available for public use and benefit wherever possible.

There is a variety of forms of statutory protection available under the Reserves Act 1977, the Land Act 1948, the Wildlife Act 1953, and subsequent amendments to these Acts. Three provisions of the Land Act are relevant. The first concerns the reservation of strips of land around lakes and along the coast, rivers and streams, for reasons of public access:

> "There shall be reserved from sale or other disposition of Crown land under this Act a strip of land *not less* than 20 metres in width -
>
> (a) Along the mean high-water mark of the sea and of its bays, inlets, and creeks:
>
> (b) Along the margin of every lake with an area in excess of 8 hectares;
>
> (c) Unless the Minister considers it unnecessary to do so, along the banks of all rivers and streams which have an average width of not less than 3 metres" (Section 58(1)) (Author's italics).

Secondly, Crown land may be set aside as a reserve under section 167(1):

"The Minister (of Lands) may ... set apart as a reserve any Crown land, and ... any foreshore ... adjacent thereto and vested in the Crown, for any purpose which in his opinion is desirable in the public interest."

Any land reserved in this manner then comes within the jurisdiction of the Reserves Act 1977, under section 2(1) of that Act.

Thirdly, under section 60(1) of the Land Act, the Land Settlement Board:

"... may ... grant or reserve any right of way ... over or under any Crown land".

Such a right of way may be needed when establishing a reserve to which the public has access rights but which otherwise lacks public access.

There is provision in the Reserves Act for a number of different kinds of reserve. These include nature reserve (section 20), scientific reserve (section 21), scenic reserve (section 19), historic reserve (section 18) and Government purpose (wildlife) reserve (section 22(2)). The extent of modification of natural features on farm development blocks will usually be such that nature and scientific reserve status is inappropriate, but this may not be so in all circumstances. However, scenic reserve status would appear eminently suitable for many of the better forest remnants, taking advantage of both their conservation value and their scenic value in a settled landscape. Historic reserve status may be appropriate in some circumstances.

Where there are high wildlife values present, provisions of the Wildlife Act 1953 (including the Wildlife Amendment Act 1980) for wildlife sanctuaries, wildlife refuges and wildlife management reserves may be appropriate. Under the Wildlife Act, Crown land required for wildlife sancturies, refuges and management reserves is to be reserved under section 167 of the Land Act 1948, and is then subject to those provisions of the Wildlife Act appropriate to the reserve category and otherwise to the Reserves Act 1977.

Where an area is set aside as a reserve, management becomes the responsibility of Wildlife Service or Department of Lands and Survey Rangers and need not be further considered here. Where valuable natural features are included in land set aside under section 58(1) of the Land Act (and this may not be infrequent), it is suggested that Reserves Rangers could be made responsible for management under a formal or informal arrangement, or alternatively the strip of Crown Land could be reserved under section 167 of the Act.

There will be many natural features however which do not meet the standards of the statutory reserves outlined above, especially on account of their small size. Nevertheless some will certainly be worthy of protection, and for these there appears to be two possibilities.

The first is retention as Crown land. For larger remnants Crown land status may be the only feasible possibility if a substantial local authority rates burden on settling farmers is to be avoided. Land retained as Crown land could then be managed under section 38 of the Reserves Act 1977 as if it were a reserve for scenic or other purposes.

However, exclusion of large numbers of forest remnants from leased or freeholded land does not appear to be a practical proposition. For these the concept of a conservation covenant under section 77 of the Reserves Act 1977 is one worth persuing[1].

A conservation covenant is an agreement whereby private or Crown lease land is to be managed in a manner that will achieve the particular purpose(s) of conservation without the Crown acquiring ownership of or the lessee's interest in the land. Such a covenant could be negotiated by the Department of Lands and Survey (on behalf of the Minister) with the settling farmers when the land is being freeholded or leased. It appears to be the ideal way of protecting smaller forest remnants and other natural features of specific value which do not meet the standards of statutory protection provisions.

Conservation covenants may be in perpetuity or may be for any specified term (section 77(2)). Usually the desired protection of natural features will be in perpetuity, so conservation covenants should be of a similar character.

When the land is subdivided, an appropriate conservation covenant should be negotiated for each unit that warrants it. There should be provision for the continued protection of all forest remnants and other natural features of value, and the covenant should specify any constraints necessary on farm operations (such as no drainage of peat

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1. The open space concept of the Queen Elizabeth the Second National Trust Act 1977 is similar, but is not relevant to the present discussion. It applies only to private land and land held under Crown lease.

swamps of scientific value). While public access would generally be desirable, it is not mandatory and need not be insisted upon if it is likely to pose undue difficulties for farm management. Conceivably a clause could be inserted that there be no clearing of indigenous forest unless there is demonstrated to be a clear need (a continuation of the Indigenous Forest Policy (Conway, 1977)). The covenant could provide for inspection of the natural features after settlement by Department of Lands and Survey Reserves Rangers. In return, Rangers might be made available to offer advice on any contemplated farm operation which could affect natural features, and they could be assigned responsibility for the maintenance of fences and other work required to protect the natural features covered by the covenant.

Negotiation of the covenant should be taken as an opportunity to elicit the goodwill of the settling farmer. The covenant could include for his/her benefit a summarised account of the forest remnants and other natural features on the farm, their significance, the work previously done to protect them, and any work still required. The farmer could be encouraged to continue a fencing-off programme. The opportunity exists to encourage an awareness of the natural values on the farm, and a sense of pride that the farmer and his/her family have become their custodian. The value of "the patch of bush out the back" is not just a duty without any reward - the recreational and educational potential of forest remnants for settling farmers and their families will be readily apparent.

Provision under a conservation covenant for local authority rates relief and/or a reduction in rent in the case of Crown lease land are possibilities which could be pursued further. They would certainly make the conservation covenant concept a much more attractive proposition to a settling farmer, especially for larger protected areas.

As conservation covenants are very much a new phenomenon, it may take time before patterns in their use become apparent. In the meantime bold experimentation in using conservation covenants to protect natural features on farm development blocks could demonstrate the wide range of possibilities inherent in the conservation covenant provisions of the 1977 Reserves Act.

In summary, it is suggested that the means of protecting natural values on farm development blocks after settlement should reflect conservation value priorities.

Specifically:

1. Any natural feature worthy of some form of statutory reserve protection, under the Reserves Act 1977, the Land Act 1948, or the Wildlife Act 1953, should be so designated.
2. Any remaining remnants of substantial size should be retained as Crown land and managed under section 38 of the Reserves Act 1977 as if they are reserves for scenic or other appropriate purposes.
3. All other valuable natural features should be protected under a conservation covenant, to be negotiated between the Department of Lands and Survey and the settling farmer when the land is being freeholded or leased.
4. The insertion of a clause in conservation covenants limiting the clearing of any other indigenous forest to that which is clearly necessary for further farm development should be considered.

It is noted that the establishment of reserves and conservation covenants requires the approval of the Minister of Lands and/or the Land Settlement Board.

RECOMMENDATIONS

22. THAT ANY NATURAL FEATURES WORTHY OF SOME FORM OF RESERVE STATUS BE SO DESIGNATED.
23. THAT ANY REMAINING REMNANTS OF SUBSTANTIAL SIZE BE RETAINED AS CROWN LAND AND MANAGED AS IF THEY ARE RESERVES.
24. THAT CONSERVATION COVENANTS BE NEGOTIATED BETWEEN THE DEPARTMENT OF LANDS AND SURVEY AND SETTLING FARMERS TO PROVIDE FOR CONTINUED PROTECTION OF ALL OTHER NATURAL FEATURES OF VALUE AFTER SETTLEMENT.
25. THAT THE POSSIBILITY OF INCLUDING PROVISION WITHIN A CONSERVATION COVENANT FOR LOCAL AUTHORITY RATES RELIEF AND/OR A REDUCTION IN CROWN LEASE RENT BE INVESTIGATED.
26. THAT INSERTION OF A CLAUSE IN CONSERVATION COVENANTS TO LIMIT CLEARING OF ANY INDIGENOUS FOREST TO THAT WHICH IS CLEARLY NECESSARY FOR FARM DEVELOPMENT BE CONSIDERED.

4.2 RECOMMENDATIONS FOR PROTECTION OF FOREST REMNANTS AND OTHER NATURAL FEATURES ON BELL HILL FARM SETTLEMENT

4.2.1 Framework for Recommendations

Specific recommendations are made below for the protection of 59 forest remnants, two peat swamps and an induced pakihi. The recommendations are formulated within the broad perspective outlined in section 4.1.1, but are based primarily on consideration of the conservation status index and of management factors.

4.2.1.1 Conservation Status Index. While there are many advantages in having a uniform system of ranking forest remnants, there are also a number of potential weaknesses. A degree of care in interpretation is needed. It should be noted that the Conservation Status Index is based on only four scientific criteria, that it provides only a limited range of scoring options, that some scoring features may be changed relatively easily by management actions, that there is considerable latitude for variation within some scoring options, and that each criterion is weighted equally rather than using a variable weighting system. Inevitably there are some anomalies. Those arising from the last factor are perhaps the most significant. In evaluating beech outliers, for example, it is clear that the community criterion should be weighted more highly than each of the other criteria[1].

A fixed weighting system undervalues any features which would score more highly on a variable system[2]. Hence in framing the recommendations below all forest remnants have been closely examined to pick out any whose conservation value is greatly underrated by its conservation status index. Most other anomalies are of a minor nature only, and are not considered further. In general, it may be assumed that the conservation status index grouped in classes of five (e.g. 51-55, 56-60, 61-65 ...) is a fairly accurate indicator of the conservation value of forest remnants not specifically cited in the recommendations below.

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1. However, while a more refined scheme for deriving a conservation status index may reduce such anomalies, experience using a number of different schemes on the same features suggests there are unlikely to be major differences in the final order of ranking (Ogle and Anderson, 1979).

2. This can be easily proved mathematically.

4.2.1.2 Management Factors. Recommendations are also made (or not made) having regard to:

- the requirements of farm development, operations and settlement;
- the effectiveness and viability of a natural feature as a functioning natural ecosystem or other conservation unit, and its size, future potential and relationships to other natural features; and
- the cost effectiveness of any necessary conservation management input (particularly the length of fencing required).

The first recommendation for each feature relates to suggested status. In this regard, each feature is assigned to one of the four options listed below. Assignment to an option reflects conservation value and amenability to conservation management, and *is intended as a guide to determine priority for any necessary management protection measures.*

A: Features of high or outstanding conservation value which meet standards of reserve status or additions to existing reserves. Formal reservation recommended.

B: Features of high conservation value which because of small size or other limitation are not suitable for formal reserve status. Conservation covenant recommended.

C: Features of medium to high actual or potential conservation value. Conservation covenant generally recommended.

D: Features of lower conservation value but still worthy of management protection measures if resources permit. Conservation covenant recommended.

If integration of nature conservation value within the farm development process is to be taken seriously on the Farm Settlement, it is considered that recommendations assigned A and B priorities should be implemented as soon as practicable and certainly by the end of the farm development period. For nature conservation purposes it would be preferable to initiate the reservation process as early as possible, but it is recognised that the approval of the Land Settlement Board is first required. If there are likely to be difficulties in obtaining formal approval at this stage in advance of settlement, it is suggested that the reserve proposals be incorporated within the overall farm settlement proposals when they are submitted to the Board. If this

procedure were to occur management of the proposed reserves could be undertaken in the interim by Reserves Rangers under an informal arrangement.

Recommendations assigned a C priority should also be implemented by the end of the development process. Those assigned a D priority should be implemented as and where resources permit. If any management protection measures of this priority are not implemented, a conservation covenant would still be preferred, together with notification to the settling farmer of the feature's conservation value(s) and recommended protection measures.

The location of all areas referred to below is shown on Figs.17, 18 and 19.

4.2.2 Blairs block - Forest Remnants and Shrublands

b1 (C.S.I. = 64; area = 10.7 ha)

b1 is located on Loopline glacial outwash terrace gravels and on a narrow degradational alluvial terrace on the banks of Piper Creek. Heavily cutover rimu-kahikatea (B1) forest on the outwash terrace now contains only scattered tall podocarps above a canopy of varying height consisting of secondary kahikatea, toatoa, kamahi and shrub species. Matai is present in the logged mixed podocarp (A4) forest beside Piper Creek. The forest understorey has been moderately grazed but there is plentiful seedling regeneration where the canopy is open.

An old tramline extends into b1 from the southeast.

At present there are fences on the northwest (Farm Settlement) and northeast boundaries of b1.

RECOMMENDATIONS

1. THAT b1 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT FENCING AROUND b1 BE COMPLETED, ALONG THE LINES SHOWN OF FIG. 17.

b3 (C.S.I. = 82; area = 37.5 ha)

This remnant is situated on low Tertiary sandstone and siltstone ridges and slopes. There is local alluvial aggradation in some gullies.

Unlogged podocarp-hardwood (C1v) forest covers about two-thirds of the area, primarily on the ridges and upper slopes. It contains many tall rimu and miro, emergent above a kamahi, quintinia, pokaka and southern rata canopy. The remainder is logged but regenerating (C1) forest of a similar type, together with some shrubby and semi-open areas. The forest understorey has been grazed by goats and other wild animals only, and is in moderately good condition. There is a comparatively high bird species richness (10 species).

A small tunnel and other workings in the headwaters of Candlelight Creek (S44: 936845) are mute evidence of goldminers' efforts late last century.

b3 is currently fenced off from the remainder of Blairs block but it has an open boundary with the immediately adjacent Mawhera State forest.

The future status and management of b3 is discussed in relation to b16 and b17 below.

b4 (C.S.I. = 68; area = 26.0 ha)

b5 (C.S.I. = 45; area = 0.3 ha)

b6 (C.S.I. = 45; area = 0.3 ha)

These three remnants are located on Loopline outwash terrace gravels, overlain in the east by a thin veneer of alluvium or solifluction deposits derived from the adjacent Tertiary hill country.

The vegetation is all heavily cutover kahikatea - rimu (B1) forest. Remaining tall podocarps are scattered and are generally of small diameter and poor form. However kahikatea sapling pole and small tree regeneration is prolific. The forest understorey is sparse, on account of both the density of the canopy and a moderate degree of grazing.

The presence of clearly visible hauler lines and an old tramline suggests these remnants may have been logged in the early milling phase and again more recently.

Eight fernbirds were recorded in the swampy vegetation between b5, b6 and b4. This is the second highest concentration of fernbirds on the Farm Settlement.

The only fence, on the eastern boundary, separates b4 from b3.

The three remnants should be protected after settlement under a conservation covenant. They should be fenced off together, and the fernbird habitat included. A suggested fenceline is shown on Fig. 17. The area within this fenceline is 28.7 ha, of which 5.1 ha is open swampy fernbird habitat.

RECOMMENDATIONS

1. THAT b4, b5 AND b6 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (C)
2. THAT b4, b5 AND b6 BE FENCED ALONG THE LINES SHOWN ON FIG. 17.

b7 (C.S.I. = 65; area = 11.0 ha)

b8 (C.S.I. = 75; area = 6.5 ha)

The conservation status indices above are assessed only on the main (A4) forest association in b7 and b8, and on the large beech outlier in b8. The values would be significantly higher if additional single tree beech outliers in both remnants were taken into account.

The two remnants are located on Loopline glacial outwash terrace gravels, and on a narrow degradational alluvial terrace on the banks of Piper Creek. The former mixed podocarp forest covering most of the area has been heavily logged and partly burnt. Remaining tall rimu, kahikatea and miro are generally scattered or in small clumps. Some matai occurs adjacent to Piper Creek. Subsequent regeneration, particularly of kahikatea, hardwoods and shrub species such as manuka, is generally plentiful.

Three beech outliers are present. The largest (1.0 ha), in the west of b8, is an impressive stand (A5) of red beech, tall podocarps and a few red beech - mountain beech hybrids. The others are single trees only, a red beech pole in b7 adjacent to Piper Creek (S44; 924833) and a red beech - mountain beech hybrid tree in the south-east corner of b8 (S44: 936827).

The forest understorey has been grazed throughout and is in fair condition only.

There is an established pattern of fencing in the vicinity of the two remnants, although the fence along the northern margin of b7 and through the western tip of b8 was not seen in the present survey.

The two remnants should be protected after settlement under a conservation covenant. Suggested fencelines, drawn on the assumption that the fence which was not seen no longer exists, are shown on Fig. 17.

Protection may be expected to have some impact on farm development, particularly by creating fencing pattern difficulties. It may be necessary to realign some existing fence lengths in the vicinity. It is hoped this may be achieved within a long-term development framework.

When the area to be protected is fenced, any gorse within it should not be sprayed as it will be suppressed by regenerating native forest within a relatively short time.

RECOMMENDATIONS

1. THAT b7 AND b8 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (B)
2. THAT b7 AND b8 BE FENCED, ALONG THE LINES SHOWN ON FIG. 17.
3. THAT WHEN THE AREA TO BE PROTECTED IS FENCED, ANY GORSE WITHIN BE NOT SPRAYED.

b10 (C.S.I. = 67; area = 31.9 ha)

b30 (C.S.I. = 71; area = 69.5 ha)

b10 and b30 are located on Loopline glacial outwash terrace gravels, on an alluvial terrace of the Arnold River, and on steep slopes between the two terraces. There is a narrow gully in the centre of b30.

There is a great variety of vegetation in the two remnants. Beech is present in b30 but not in b10[1]. Red beech (A5) occurs in the bottom of the gully in b30 and on the steep hill slopes in its actively eroding upper reaches. Both red and mountain beech are present on the upper terrace about the head of the gully. Heavily logged kahikatea (A3) forest on the Arnold River alluvial terrace in b10 now has few tall podocarps, but there is dense advanced regeneration of kahikatea, kamahi and other species. Logged podocarp-hardwood (C1) forest predominates on the steep slopes in both remnants, containing generally scattered tall rimu and miro emergent above a canopy of kamahi, quintinia, pokaka, secondary rimu, toatoa, marbleleaf and other species. The original forest patterns on the upper terraces of the two remnants have been obscured by heavy logging and by possible burning of an area in b30. Tall podocarps now are either scattered or absent, and the second growth forest varies in species composition from kahikatea, kamahi and rimu through to toatoa, silver pine and cedar. Burnt beech stumps on cleared land northwest of b30 suggest beech was formerly more widespread on the Loopline outwash terrace in the vicinity, and it is possible that the toatoa-silver pine-cedar community in b30 is a fire-induced community which has replaced beech.

The forest understorey has been heavily grazed throughout b10, but in b30 the extent of grazing appears to be closely related to the density of the undergrowth and its accessibility to stock.

The remains of an old pack track or overgrown vehicle track are present on legal road on the north bank of the Arnold River between b10 and b30. There are farm tracks through the centres of both remnants, the one in b10 based on an old tramline.

Gorse occurs on some of the old logging tracks in b30. Spray drift from nearby gorse spraying operations has caused canopy dieoff on some forest margins.

1. Almost certainly the beech in b30 was once joined to the main beech stands further down the Arnold River valley. However forest clearance has obscured the patterns of beech distribution and upstream migration in the vicinity.

There are fences on the western edge of b10 and at the mouth of the gully in b30. A fence was recently erected along the northern boundaries of b10 and b30.

The two remnants together constitute a substantial block of forest (101.4 ha). The forest cover is clearly important for maintaining the stability of the steep slopes present, but the two remnants lack significant qualities which would make them worthy of formal reserve status. Two possibilities for future status and management are presented:

1. The two remnants could be retained after settlement as Crown land and be managed as a reserve for scenic and water and soil conservation purposes (section 38, Reserves Act 1977). There should be provision for continued farm access through to the Arnold River flats.
2. Alternatively they could be protected under a conservation covenant with the settling farmer. Again there should be provision for continued farm access.

Fencing around the two remnants should be completed in either case.

RECOMMENDATIONS

1. THAT b10 AND b30 BE PROTECTED AFTER SETTLEMENT EITHER BY:
   A. RETENTION AS CROWN LAND AND MANAGEMENT FOR SCENIC AND WATER AND SOIL CONSERVATION PURPOSES, WITH PROVISION FOR CONTINUED FARM ACCESS; OR
   B. INCLUSION WITHIN A CONSERVATION COVENANT. (B)
2. THAT FENCING AROUND b10 AND b30 BE COMPLETED, ALONG THE LINES SHOWN ON FIG. 17.

b13 (C.S.I. = 62; area = 8.2 ha)

This remnant is situated on steep slopes between two Loopline glacial outwash terrace flights, and on the edge of the upper terrace. Logged podocarp-hardwood (C1) forest on the steep slopes contains a few tall rimu and miro above the kamahi, quintinia and secondary rimu and kahikatea canopy. On the upper terrace the heavily logged former rimu (B2) forest now has only scattered tall rimu but plentiful advanced regeneration of rimu, kahikatea and hardwoods. The forest understorey throughout has been severely depleted by grazing.

b13 is fenced along its northern edge, and another fence bisects the stand in the west.

b13 should be protected after settlement under a conservation covenant. Fencing off should be completed. A small length of fence which presently cuts through b13 would become redundant under this recommendation.

RECOMMENDATIONS

1. THAT b13 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)

2. THAT FENCING AROUND b13 BE COMPLETED, AS SHOWN ON FIG. 17.

b16 (C.S.I. = 66; area = 20.5 ha)

b17 (C.S.I. = 81; area = 42.0 ha)[1]

These two remnants are located primarily on low Tertiary sandstone and siltstone ridges and hill slopes. The lower slopes of the southern part of b16 may be overlain by Loopline glacial outwash gravels. A deeply incised gully and small creek is present in the north of b17.

The predominant vegetation is unlogged podocarp-hardwood (D1v) forest (43.6 ha), consisting of moderately dense tall rimu and miro emergent above a canopy of kamahi, quintinia, southern rata, pokaka, toro and other hardwoods. The remainder is logged but regenerating forest of a similar kind, containing fewer tall podocarps, more sapling and pole rimu and kahikatea, and more seral hardwoods such as wineberry, fuchsia and marbleleaf. There are small peripheral shrubland areas in early stages of regeneration. The forest understorey has been grazed by wild animals only and is in relatively good condition. A high forest bird species richness (10 species) was recorded.

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1. The dividing line between b16 and b17 is somewhat arbitrary. If an additional 1.2 ha of unlogged forest from b16 was included in b17, the C.S.I. value of b17 would be four percentage points higher and the second highest on the Farm Settlement.

Relics of former goldmining activities are present at two sites in b17 (shown on Fig. 17). One is a tunnel of unknown length dug into the hillside,and the other consists of various workings in the deeply incised small creek. The former Kotuku - Notown Pack Track, which was evidently a major travel route in the goldmining era and even today is in good condition, is on Road reserve or State forest immediately east of b16 and b17.

Both remnants are fenced off from the rest of Blairs block.

The future status and management of the two remnants must be considered in relation to a number of factors:

- the desire of the Department of Lands and Survey and the New Zealand Forest Service to rationalise land boundaries in the vicinity[1];
- the high conservation value of the two remnants;
- the scenic value of the prominently visible south and west slopes of b17 (and of Mawhera State forest below Molloys Lookout);
- an amenity and potential scientific value arising from the fact that this is the closest area of unlogged forest to the Christchurch Teachers College Lodge at Kotuku;
- the historical values present, including the goldmining relics in b17 and the Kotuku - Notown Pack Track; and
- the possibility of including b3 (which is similar in many respects to b17 but lacks comparable amenity value) in any boundary rationalisation.

The proposal presented for consideration below assumes that the area of pasture at present in Mawhera State forest is transferred to the Farm Settlement.

It is suggested that b3, b17 and the northern part of b16 (total area 92.0 ha) all be transferred to Mawhera State forest. Most of b17, and all of the State forest south and west of Molloys Lookout which is prominently visible from the Kotuku - Kokiri Road, should then be designated as an amenity zone in the Mawhera State forest management plan. A small part of b17 and all of the unlogged forest in b3 could then be made available for logging.

Logging in b17 should be confined to that area up to the ridge *north* of the deeply incised creek in the centre of the remnant (see Fig. 17). This is to protect the riparian values of the creek, the gold workings in its bottom, and the steep slopes above the creek. Logging operations in b3 should avoid damage to the gold workings there.

1. A proposal presently under consideration is to transfer the area of developed pasture northwest of b17 from the Forest Service to the Department, in exchange for adding b17 to Mawhera State forest. b17 would then be open for logging by the Forest Service.

Given conflicting resource use possibilities, this proposal is considered the most desirable in relation to the protection of conservation, scenic, amenity and historical values. It is hoped that the suggestions of an amenity zone below Molloys Lookout and the exchange of unlogged forest in b3 for logging purposes in preference to that in b17 are acceptable to the Forest Service. Retention of a natural forest cover below Molloys Lookout may already be planned by the Service.

If the Forest Service is unable to agree to this proposal, the possibility of separate reserve status for b16 and b17 should be investigated.

As a corollary to the proposal, the southern part of b16, which is also prominent visually from the Kotuku - Kokiri Road, should be protected after settlement under a conservation covenant. A north facing slope within the present fenceline has been burnt fairly recently but young regeneration is plentiful.

RECOMMENDATIONS

1. THAT THE DEPARTMENT NEGOTIATE WITH THE FOREST SERVICE WITH A VIEW TO PROTECTING THE CONSERVATION, SCENIC, AMENITY AND HISTORICAL VALUES OF b16 AND b17, SPECIFICALLY BY:
   A. TRANSFERRING b3, b17 AND THE NORTHERN PART OF b16 TO MAWHERA STATE FOREST (IN EXCHANGE FOR THE PASTURE LAND CURRENTLY IN STATE FOREST);
   B. SEEKING DESIGNATION OF MOST OF b17 AND THE SOUTH AND WEST SLOPES OF MAWHERA STATE FOREST BELOW MOLLOYS LOOKOUT AS AN AMENITY ZONE;
   C. ALLOWING LOGGING IN b3 AND THAT PART OF b17 SHOWN ON FIG. 17, IF THIS IS NECESSARY.(A)
2. THAT THE SOUTHERN PART OF b16 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (C)

b19 (C.S.I. = 45; area = 0.4 ha)

b20 (C.S.I. = 64; area = 22.2 ha)

b19 and b20 are located on Loopline glacial outwash terrace gravels. Both stands are bisected by small creeks.

b19 is a small stand of young red and mountain beech trees, and a few podocarps. It has been intensively grazed and the forest understorey is browsed out.

The vegetation in b20 is predominantly heavily cutover mixed podocarp forest. There are scattered tall kahikatea, rimu, cedar and matai (adjacent to the creek), emergent above a canopy of varying height containing toatoa, secondary kahikatea and rimu, silver pine, wineberry and manuka. The remainder consists of small patches of red and mountain beech, and a partly sprayed manuka and gorse shrubland. The forest understorey has been grazed wherever it is sufficiently open to be accessible to stock.

The significance of b19 and b20 lies in their relationship to the beech-podocarp boundary. At present both are isolated from the main beech stands in the Arnold River valley. However b20 is only 400 m distant from beech in b30, and the presence of burnt beech stumps around b19, b20 and the north side of b30 suggests beech forest was once considerably more widespread on this part of the Loopline outwash terrace. It is probable therefore that beech in b19 and b20 was once contiguous with the main beech stands and that the two remnants defined the limit of upstream beech migration in the vicinity. Possibly the isolated red and mountain beech stand at the eastern tip of b20 may have been an outlier.

Both remnants are bisected by a common fence. New fences have recently been erected on the northern and western edges of b20.

Both remnants should be protected after settlement under a conservation covenant. Fencing around b20 should be completed, but excluding the sprayed gorse shrubland on the southern edge. Fencing around b19 would be desirable to guarantee its continued long-term existance.

RECOMMENDATIONS

1. THAT b19 AND b20 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (B)
2. THAT FENCING AROUND b19 AND b20 BE COMPLETED, ALONG THE LINES SHOWN ON FIG. 17.

b22 (C.S.I. = 56; area = 5.2 ha)

This remnant is situated on the ridge and slopes of a small hill which is underlain by Tertiary sandstone and siltstone deposits. The vegetation is predominantly logged podocarp-hardwood (D1) forest, containing some tall miro and rimu emergent above a canopy of kamahi, quintinia, pokaka and other hardwoods. A few tall red beech trees on alluvium adjacent to Deep Creek are part of the Deep Creek beech outlier. The forest understorey has been lightly grazed by stock.

The stand has considerable scenic and amenity value. It is adjacent to the Kotuku - Kokiri Road and is a visually prominent feature from the road as it climbs up from the Deep Creek bridge. Remains of the Kotuku - Notown Pack Track are evident along the edge of Deep Creek.

Fences exist on the roadside edge and along Deep Creek, but are not in good condition.

There appear to be two options for the future status and management of b22. It could be protected after settlement under a conservation covenant, or it could be retained as Crown land and be managed as a reserve for scenic purposes under section 38 of the Reserves Act 1977. The latter option is preferable for conservation purposes. Fencing should be completed in either case.

RECOMMENDATIONS

1. THAT b22 BE EITHER:
   A. RETAINED AS CROWN LAND AND MANAGED AS A RESERVE FOR SCENIC PURPOSES; OR
   B. PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (C)
2. THAT FENCING AROUND b22 BE COMPLETED, ALONG THE LINES SHOWN ON FIG. 17.

b28 (C.S.I. = 84; area = 54.9 ha)

b29 (C.S.I. = 69; area = 23.4 ha)

These two remnants are located primarily on Loopline morainic hill country. A small part of b28 is on an alluvial terrace adjacent to the Arnold River.

The vegetation is predominantly cutover podocarp-hardwood (C1) forest. It contains tall, generally scattered rimu, miro, cedar and other podocarps, emergent above a canopy of kamahi, quintinia, toatoa, secondary rimu and kahikatea, and other species. Small areas of heavily cutover kahikatea (A3) swamp forest and unlogged kahikatea-matai (A2v) forest occur in b28 on the Arnold River alluvial terrace. Heavily cutover rimu (B2) forest exists on a small high terrace in b29. A multiplicity of logging tracks in b29 indicates the stand has been logged (or re-logged) fairly recently. The forest understorey throughout has been grazed by stock and wild animals,but recent fencing off should initiate a recovery. A high forest bird species richness (10 species) was recorded, a consequence no doubt of the substantial size (228 ha) of the immediately adjacent Arnold River I scenic reserve.

Recently erected fences separate the two remnants from the rest of Blairs block. A small part of b28 was excluded however. The south-eastern boundary of b28 is not fenced. Spray drift from adjacent gorse spraying operations has caused canopy die-off on some forest margins.

The two remnants are of high conservation value and are clearly worthy of addition to the adjacent Arnold River I scenic reserve. This reserve, ranked as one of the most valuable in North Westland, encompasses practically all of the block of forest on the north bank of the Arnold River in the vicinity of the Kaimata dam, with the exception of b28 and b29. On the ground, the two remnants are an integral part of this block of forest and their incorporation in the reserve would rationalise an existing situation.

Addition of substantial areas of cutover forest should not be seen as "diluting" the quality of the reserve. In fact it increases its diversity of vegetation and its wildlife conservation value. Regeneration will ensure a rapid recovery of its aesthetic value.

b28 needs to be fenced in the south-east, along the boundary with the land leased to the adjacent landowner.

Note: A small part of the boundary between Blairs block and the Arnold River I scenic reserve, along the north-west edge of the reserve, is yet to be fenced. The boundary should be surveyed prior to fencing.

RECOMMENDATIONS

1. THAT b28 AND b29 BE ADDED TO THE ARNOLD RIVER I SCENIC RESERVE. (A)
2. THAT FENCING AROUND b28 AND BETWEEN BLAIRS BLOCK AND THE ARNOLD RIVER I SCENIC RESERVE BE COMPLETED, ALONG THE LINES SHOWN ON FIG. 17.

b32 (C.S.I. = 69; area = 55 ha)

b32 lies within a system of degradational alluvial terraces incised by Piper Creek into the adjacent Loopline outwash terrace. The basin is shallow and narrow in the east but becomes wider and deeper towards the west.

The vegetation is of varying height and is somewhat patchy as a result of past logging and burning. Red beech trees, poles or saplings are generally predominant, although the species is only partly established in the uppermost part of the Piper Creek basin. Rimu, miro, matai, cedar, kamahi, toatoa and secondary kahikatea are also present, but in low numbers in dense beech forest. Where accessible the forest understorey has been grazed by stock, goats and other animals. Clearly visible hauler lines indicate recent logging (or re-logging).

The only fence in the vicinity of b32 extends north-west from the Kotuku-Kokiri Road along the north-east boundary of this block.

The remnant is of substantial size but lacks significant qualities which would make it worthy of formal reserve status. It could be retained after settlement as Crown land and be managed as a reserve for scenic and other purposes under section 38 of the Reserve Act 1977, or it could be protected under a conservation covenant. In either case it should be fenced off. There should be provision for continued farm access through b32 if this is necessary. The south-west (Farm Settlement) boundary should be fenced if stock from neighbouring land has access to b32.

RECOMMENDATIONS

1. THAT b32 BE PROTECTED AFTER SETTLEMENT EITHER BY:
   A. RETENTION AS CROWN LAND AND MANAGEMENT FOR SCENIC AND OTHER PURPOSES, WITH PROVISION FOR CONTINUED FARM ACCESS IF NECESSARY; OR
   B. INCLUSION WITHIN A CONSERVATION COVENANT. (B)
2. THAT b32 BE FENCED, IN THE FIRST INSTANCE ALONG THE LINES SHOWN ON FIG. 17.

4.2.3. Weka Block

4.2.3.1 Forest Remnants and Shrublands

w4 (C.S.I. = 68; area = 17.7 ha)

w5 (C.S.I. = 64; area = 17.3 ha)

w12 (C.S.I. = 58; area = 22.8 ha)

There is a variety of landforms in these three remnants. w12 and the eastern part of w4 are located on a deeply incised system of degradational alluvial terraces cut by Deep Creek into adjacent formations. The eastern part of w5 is on Loopline glacial outwash terrace. Remaining parts of w4 and w5 are on Loopline morainic hill slopes. Deep Creek flows through a deep gorge on the western boundary of the three remnants, and underlying Tertiary sandstone and siltstone formations are exposed there. There is evidence of gases and oil seeping to the surface in the riverbed.

The vegetation is similarly varied. There is a small area of unlogged podocarp-hardwood (C1v) association in w4, on a very steep slope between Deep Creek and the outwash terrace above. The forest understorey is in good condition. Elsewhere the forest has been highly modified by logging and burning. Old red beech trees and regenerating pole stands (A5 association) occur on the alluvial flats, a part of the Deep Creek beech outlier. Podocarp-hardwood (C1) forest on the morainic hill slopes has been heavily logged, and only a few emergent rimu, miro and kahikatea remain. However there is plentiful rimu, kahikatea and hardwood regeneration. Kahikatea-rimu (B1) forest on the Loopline outwash terrace was very heavily logged,but dense kahikatea sapling and pole regeneration is now present. There are smaller areas of fire-induced shrubland communities which are regenerating to varying degrees in native forest species.

Grazing effects on the forest understorey are varied, depending greatly on accessibility to stock.

There are old logging or farm tracks through w12, and between w4 and w5. The overgrown remains of an old tramline and gold-sluicing channel are present in w12 (S51: 985799). An old gold sluicing face is also present at the lower end of the Deep Creek gorge (S51: 968789).

The new Deep Creek road runs along the southern edge of the three remnants. However the road lies below the forest remnants, and their potential scenic value is reduced by the limited visibility.

There is a fence along the southern boundary of w4 and w5, adjacent to the Deep Creek road. In 1979 the ground was prepared for a new fence along the south-eastern boundary of w12 and the eastern boundary of w5. The recommendations below assume the fence has been or will be completed.

The three remnants together constitute a relatively large, discrete and isolated block of forest, but they lack specific conservation or scenic values which might make reserve status appropriate. Therefore it is recommended that they be retained as Crown land and be managed as a reserve for scenic purposes under section 38 of the Reserves Act 1977. The status of the block can be re-evaluated in the future should circumstances of possible land use options change. If development is ever chosen, retention and fencing of the higher conservation value w4 and w12 along Deep Creek would be preferred. The strip of Crown land reserved from sale along Deep Creek should remain.

In the interim the land should be de-stocked, to facilitate regeneration in the small open areas within the present fences. The fence along the eastern margin could be re-located closer to the forest edge if this is desired for farm development purposes.

The total area within the present fenceline is 65.7 ha.

RECOMMENDATIONS

1. THAT w4, w5 AND w12 BE RETAINED AS CROWN LAND, AND BE MANAGED AS A RESERVE FOR SCENIC PURPOSES. (B)
2. THAT THEIR STATUS BE RE-EVALUATED IF AND WHEN CIRCUMSTANCES OF POSSIBLE LAND USE OPTIONS CHANGE.
3. THAT THE STRIP OF CROWN LAND RESERVED FROM SALE ALONG DEEP CREEK BE RETAINED.

w13 (C.S.I. = 58; area = 5.1 ha)

w13 is centred on a wide but deep gully incised by a small creek into the Loopline glacial outwash terrace. The gully opens on to the alluvial terrace beside Deep Creek immediately to the north. There are also smaller areas of outwash terrace and steep cliff face.

In the gully is a podocarp-hardwood (C1) forest remnant which has been lightly logged, if at all. Tall rimu and miro, some of large diameter, rise above the kamahi, toatoa and cedar subcanopy. The stand is significant as there is only one other occurrence on the Farm Settlement (in r76) of forest on similar landform in comparable condition.

Additionally there are small areas of dense fire-induced manuka shrubland on the outwash terrace, and of heavily logged podocarp-hardwood forest on the northern cliff face. The forest understorey throughout has been somewhat depleted by grazing.

There are two fences in the vicinity. One runs very close to the western margin, the other is on the alluvial terrace on the northern margin. The latter was under construction in 1979 and is assumed to be completed.

This remnant should be protected after settlement under a conservation covenant. The suggested fenceline shown in Fig. 18 is routed to take advantage of existing fences and in relation to terrain.

The area within the recommended fenceline is 5.8 ha.

RECOMMENDATIONS

1. THAT w13 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT (C).
2. THAT w13 BE FENCED ALONG THE LINES SHOWN ON FIG. 18.

w18 (C.S.I. = 51; area = 8.8 ha)
w19 (C.S.I. = 75; area = 45.2 ha)
w34 (C.S.I. = 74; area = 28.0 ha)
w37 (C.S.I. = 70; area = 12.1 ha)
r1 (C.S.I. = 63; area = 9.7 ha)

These five forest remnants are treated together as they form one contiguous piece of forest along Deep Creek.

The five remnants are located primarily on a system of degradational alluvial terraces incised by Deep Creek into the surrounding Loopline glacial outwash terrace. There are smaller areas of outwash terrace, and hill slopes between terraces.

The vegetation is varied, reflecting changes in landform and soil conditions and past logging and burning. The five remnants together constitute the largest single remaining part of the Deep Creek beech outlier. Red beech dominant (A5) communities on alluvial terraces and slopes make up the majority of the vegetation. They range from dense regenerating pole stands to scattered large trees within a shrub-hardwood matrix, and may contain occasional kahikatea, matai, cedar, and other podocarps. Mountain beech dominant (B5) communities occur on parts of the Loopline outwash terrace and on intermediate terraces. A small but valuable outlier of silver beech is found in w19 (see section 2.5.4.3).

There are smaller areas of non-beech communities present, including an attractive stand of large but poor form kahikatea and matai (A2 association) in w37. Fire-induced regenerating shrublands are present along the southern edges of the five remnants.

The forest understorey appears to be relatively inaccessible to stock. Generally it has been only lightly grazed and is in fairly good condition.

All five remnants are adjacent to Deep Creek, and so have a riparian value. Retention of the surrounding forest vegetation is important for maintaining the balances of the river ecosystem.

A fence was recently erected along the entire southern edge of the five remnants. The fence generally follows the forest edge, but small areas are excluded in a few places. The total area within the present fences is 94.9 ha.

An old tramline extending west-east through w19 adds an historical aspect to the remnants.

Consideration of the future status and management of the five remnants is hampered by their relative inaccessibility, their elongate shape, and their legal status. Currently w19, w34, w37 and r1 are in Mawhera State forest, while part of w18 is Crown land reserved from sale under section 58(1) of the Land Act 1948 and the other part is Crown land.

Two options are listed below for consideration.

1. The present strip of Crown land reserved from sale along the south bank of Deep Creek could be extended upstream to include all of the five remnants between the new fence and Deep Creek. This option would provide for public access along the length of Deep Creek.
2. w19, w34, w37 and r1 could be retained as State forest and, together with a suitable strip on the north bank of Deep Creek, be designated as a riparian zone in the Mawhera State Forest Management Plan. Such a designation would be in harmony with the zoning of adjacent forest - the Deep Creek ecological reserve in the east, and the (probable) protection zone on the steep slopes in the west. Since Mawhera State forest is not an open indigenous forest, there should be specific provision for public access rights in the riparian zone. To tidy up, the strip of Crown land reserved from sale along Deep Creek should be extended to include all of w18.

RECOMMENDATIONS

1. THAT ALL w18 LYING BETWEEN THE PRESENT FENCE AND DEEP CREEK BE DESIGNATED CROWN LAND RESERVED FROM SALE UNDER SECTION 58(1) OF THE LAND ACT 1948. (B)
2. THAT ALL OF w19, w34, w37 AND r1 LYING BETWEEN THE PRESENT FENCE AND DEEP CREEK BE DESIGNATED EITHER:
   A. CROWN LAND RESERVED FROM SALE UNDER SECTION 58(1) OF THE LAND ACT 1948; OR
   B. A RIPARIAN ZONE WITHIN THE MAWHERA STATE FOREST MANAGEMENT PLAN, WITH RIGHTS OF PUBLIC ACCESS. (B)

w 32 (C.S.I. = 81; area = 28.1 ha)

w38 (C.S.I. = 69; area = 5.6 ha)

w32 and w38 are divided by the new Deep Creek road, but are treated together for convenience. They are of high conservation value, with w32 being ranked in the top five forest remnants on the Farm Settlement.

The two remnants are located on Loopline glacial outwash terrace gravels. Of principal interest are the 8.8 ha of unlogged dense rimu (B2v) forest, and the 2.0 ha of rimu-kahikatea (B1v) forest in similar condition. Such forest is now rare in North Westland. It is better represented on the Farm Settlement only by the B2v stand in w41. There are additional substantial areas of similar forest which have been logged to varying degrees but are still in relatively good condition.

In general the forest understorey is in reasonable condition, but it has been severely depleted by grazing in some peripheral areas.

There are fences along the southern and eastern edges of w32, and along the northern and eastern edges of w38. A recently cut drain extending through the north-east of w32 has exposed the remains of what was probably Marshall's silver pine mill (Morgan, 1911). The site is on the northern edge of w32 (S52: 018792). Ponding in several dead-end drains off the road edge of w32 has caused some rimu tree mortality.

The future status and management of the two remnants need to be considered in relation to their legal status and to the very similar w40 and w41 nearby. In comparison with w40 and w41, the new Deep Creek county road bestows a higher scenic value on w32 and w38, but the former have superior conservation value and are therefore preferred for reserve status. Legally the land title to w32 and w38 still belongs to the New Zealand Forest Service. It has released the land to the Department of Lands and Survey for farm development purposes, but may have retained timber rights.

Three options are listed below for consideration. All will require negotiation with the Forest Service.

1. The land could be retained as State forest and be designated as an amenity zone in the Mawhera State Forest Management Plan.
2. The two remnants could be designated Crown land and be managed as a reserve for scenic purposes under section 38 of the Reserves Act 1977.

3. The two remnants could be protected after settlement under a conservation covenant.

In all cases fencing around the two remnants should be completed. The total area within the recommended fencelines is 37.7 ha, including a 2.9 ha open and low shrubland area. The open area may be expected to regenerate rapidly when de-stocked.

RECOMMENDATIONS

1. THAT, IN NEGOTIATION WITH THE NEW ZEALAND FOREST SERVICE, THE DEPARTMENT OF LANDS AND SURVEY SEED TO PROTECT w32 AND w38 EITHER BY THEIR:
   A. RETENTION AS STATE FOREST AND DESIGNATION AS AN AMENITY RESERVE IN THE MAWHERA STATE FOREST MANAGEMENT PLAN; OR
   B. DESIGNATION AS CROWN LAND AND SUBSEQUENT MANAGEMENT AS A RESERVE FOR SCENIC PURPOSES; OR
   C. INCLUSION WITHIN A CONSERVATION COVENANT. (B)
2. THAT FENCING AROUND w32 AND w38 BE COMPLETED, ALONG THE LINES SHOWN ON FIG. 18.

w33 (C.S.I. = 65; area = 22.0 ha)

w33 is located on the Loopline glacial outwash terrace. Its vegetation, which was extensively logged in the past and partly burnt, consists of remnants of tall dense rimu and rimu-kahikatea forest (B1 and B2 associations), plus substantial areas of manuka dominant shrublands. Podocarp density in the forest remnants is generally low and the canopy is now mostly toatoa, kamahi, tall manuka, and limited advanced podocarp regeneration. Young native tree species are beginning to regenerate under the manuka shrubland. In general the forest understorey has been heavily grazed around the margins but is in better condition in the interior.

There are two drains cutting through w33. There is a fence along the western margin.

Legally the land title to w33 still belongs to the New Zealand Forest Service. It is considered that w33 would be best protected after settlement by its inclusion within a conservation covenant. The Department of Lands and Survey will need to negotiate with the Forest Service to achieve this. w33 should be fenced (provided this does not pose excessive grazing control difficulties in surrounding paddocks).

The area within the recommended fenceline is 26.8 ha, including a 2.2 ha open area.

RECOMMENDATIONS

1. THAT THE DEPARTMENT NEGOTIATE WITH THE NEW ZEALAND FOREST SERVICE WITH A VIEW TO PROTECTING w33 BY ITS INCLUSION IN A CONSERVATION COVENANT. (D)
2. THAT w23 BE FENCED, ALONG THE LINES SHOWN ON FIG. 18.

w40 (C.S.I. = 69; area = 40.0 ha)

w41 (C.S.I. = 84; area = 34.0 ha)

These two adjacent forest remnants are located primarily on morainic ridges and slopes of the Loopline formation. There is also a glacial outwash terrace in the east, and a small gully and creek in the south-east.

w40 and w41 together are the largest single forest remnant on the Farm Settlement w41 has one of the highest conservation values. The feature of prime conservation interest is the 22 ha stand of tall unlogged dense rimu (B2v) forest on the eastern terrace. Such forest on young glacial landforms is now very rare in North Westland, and is not represented in reserve systems[1]. Additionally there is about 48 ha of logged but regenerating podocarp-hardwood (C1) forest, and a small area of heavily cutover rimu (B2) forest. There are some large southern rata trees in the south-east corner of w41, one of the few occurrences of this species on the young glacial landforms of the Farm Settlement.

The understorey under the B2v forest has been lightly grazed but is still in fairly good condition. Elsewhere the understorey has been heavily grazed. Stock grazing w40 have gained access to w41 via a damaged fence separating the two remnants or via an unfenced boundary with adjoining land.

w40 and w41 are now completely fenced off except for a small length along the southern (Farm Settlement) boundary. Small areas of open land are included within the present fenceline, while some forest areas are excluded (including remnants w42 and w43).

The two remnants together are clearly worthy of formal reserve status. Not only do they have high conservation value but the unlogged rimu forest in particular has a potential scenic value in being the most attractive piece of forest on the Farm Settlement. Scenic reserve status is strongly recommended.

There are a number of factors to be considered in implementing this proposal:

1. As first steps, w40 should be immediately de-stocked and fencing along the southern (Farm Settlement) boundary of w41 should be completed. The small open areas within the fencelines may then be expected to regenerate rapidly.

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1. The same type of forest exists in the Lake Kaniere scenic reserve, outside North Westland as defined here. There is an area of lower density rimu forest in the Deadman ecological reserve in Mawhera State forest, but this is on a very much older glacial surface and the forest is ecologically quite distinct from that in w41.

2. A scenic reserve requires some means of public access, but presently there is neither formed nor legal road access to the proposed reserve. The nearest road is the new Deep Creek road on the north part of Weka block, about one kilometre to the north. A farm track branches off this to within 100 metres of the proposed reserve. To fulfil the access requirement, the possibility of a public right of way under section 60(1) of the Land Act 1948 is suggested, following the farm track and extending from it towards the forest at some suitable point. It should be borne in mind that the proposed reserve is unlikely to be visited much because of its relative inaccessibility, and the spectre of large numbers of people wanting access over farm land is unlikely.
3. Legally the land title to all of the proposed reserve except the south-east corner still belongs to the New Zealand Forest Service. It has released the land to the Department of Lands and Survey for farm development purposes under a Land Use Committee agreement, but has probably retained timber rights. If so negotiation with the Forest Service will be required. The value of w40 and w41 to the Forest Service scientific reservation programme should be pointed out, particularly that this type of dense rimu forest is not represented in State forest reserve systems in Westland. The provisions for reservation under the Reserves Act 1977 appear to be more suitable than those in the Forests Act 1949 .
4. To rationalise land use patterns, a small re-alignment of fences around w40 to include an additional area of forest and exclude some open pasture would be preferable. The total area within this recommended fenceline is 84.2 ha.

RECOMMENDATIONS

1. THAT w40 AND w41 BE CREATED A SCENIC RESERVE. (A)
2. THAT w40 BE IMMEDIATELY DE-STOCKED.
3. THAT FENCING AROUND w41 BE COMPLETED AND AROUND w40 BE RE-ALIGNED, AS SHOWN ON FIG.18.
4. THAT THE DEPARTMENT NEGOTIATE WITH THE NEW ZEALAND FOREST SERVICE WITH A VIEW TO IMPLEMENTING RECOMMENDATION 1.

w58 (C.S.I. = 45; area = 0.9 ha)

w58 is situated on a nearly horizontal toe-slope of a Loopline morainic ridge. It is a small but valuable beech outlier, separated by over two kilometres from the nearest beech stands on Deep Creek.

The vegetation is predominantly young red and mountain beech (and hybrid) poles and trees. Large decaying beech stumps indicate the outlier is at least one beech generation old. There are several clumps of beech sapling and pole regeneration in the fire-induced manuka dominant shrublands around the eastern margins. The forest understorey has been practically eliminated by heavy and prolonged grazing, and the forest floor consists mostly of weeds and disturbed organic soil.

The stand is located in the middle of a paddock. There are no fences in the immediate vicinity.

w58 should be protected after settlement under a conservation covenant. To improve its long-term viability, the shrubland margins should be included when fencing it off. The total area within the recommended fenceline is 1.2 ha.

RECOMMENDATIONS

1. THAT w58 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (B)
2. THAT w58 BE FENCED, AS SHOWN ON FIG. 18.

4.2.3.2 Nan's Kettle. Nan's Kettle (area = 1.3 ha) is a partly infilled lake within a glacial hollow situated north-west of the airstrip on Weka block. There is a small tarn in its centre. (See Fig. 18 for its location, and section 2.5.4.1 for a brief description.)

Nan's Kettle is one of several Aranuian (post-glacial) peat accummulations in North Westland which were analysed by Moar (1971) for historical pollen. These analyses are the basis of present scientific understanding of Aranuian vegetation development in the region. Nan's Kettle is therefore an important scientific reference site and should be protected.

In considering recommendations, a distinction needs to be drawn between surface and subsurface features. On the surface, the natural vegetation on the accumulated peat has been irreparably modified by burning. Therefore grazing and other surface activities may be continued, provided their effects do not extend below the surface. If deep pugging by cattle occurs, it would be preferable to restrict the surrounding paddock to sheep grazing only. The tarn should not be filled in.

The principal value of Nan's Kettle lies in the pollen record in the five metres of peat below the surface. The main threats to this are peat mining, drainage of the tarn and surrounding swamp, or other subsurface activities. Peat is destroyed when water protecting it from oxidation is drained, so it is imperative that the tarn and surrounding swamp be *not* drained, and that the impounding moraine on the south edge be retained[1]. Peat mining, which directly destroys the pollen record, is unlikely on a commercial scale in the foreseeable future as the quantity of peat in Nan's Kettle is small. The danger of casual extraction for horticultural purposes remains.

It is therefore recommended that there be appropriate designation in the farm Management Plan (for the development period) and in a conservation covenant (after settlement) to protect Nan's Kettle from infilling, drainage of the tarn and surrounding swamp, peat mining, or other deleterious subsurface modification.

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1. The low barrier about the outlet stream in the south-east corner has already been enlarged by digging, and the water-table may have been lowered slightly as a consequence.

RECOMMENDATION

1. THAT THERE BE APPROPRIATE DESIGNATION IN THE FARM MANAGEMENT PLAN, AND IN A POST-SETTLEMENT CONSERVATION COVENANT, TO PROTECT NAN'S KETTLE FROM INFILLING, DRAINAGE OF THE TARN AND SURROUNDING SWAMP, PEAT MINING, OR OTHER SUBSURFACE MODIFICATION. (B)

4.2.4 Ruru block

4.2.4.1 Forest Remnants and Shrublands.

r1 (C.S.I. = 63; area = 9.7 ha)

See Weka block (section 4.2.3.1) and Fig. 19.

r2 (C.S.I. = 93; area = 61.0 ha)

This remnant has the highest conservation value of any on the Farm Settlement. Among its outstanding features are its large area, the high proportion of only slightly modified podocarp-beech and beech (A5) forest on alluvial soils, a small area of tall terrace rimu (B2v) forest, the high forest bird species richness (11 species) and the only definite occurrence of the S.I. robin on the Farm Settlement. Its beech forest is close to the upstream limit of the Deep Creek beech outlier on Jones and Deep Creeks.

The area is adjacent to the Deep Creek ecological reserve in Mawhera State forest. Except for a very small extension on its western tip, the whole area is now completely fenced off from the rest of Ruru block. There is a fence on the eastern (Farm Settlement) boundary. A road is being constructed by the Ministry of Works and Development (for the Grey County Council) along the northern boundary, between the Farm Settlement and the Deep Creek ecological reserve (see section 4.1.3.3 regarding its impact on scenic and natural values).

r2 is clearly worthy of formal reserve status. Before the road was constructed, addition to the Deep Creek ecological reserve would have been preferable as it would have added a significant area of beech forest to a reserve which now inadequately represents the beech-podocarp boundary in North Westland (section 3.3.5). However, the areas are now disjunct. Separate scenic reserve status is therefore recommended, to take advantage also of its location adjacent to what may become an important county road. The adjoining pakihi immediately east of the Deep Creek bridge has high scientific value (section 4.2.4.2) and should be included.

It is important that the Department of Lands and Survey liaise urgently with the Ministry of Works and the Forest Service to develop what remains of the scenic potential of the road as it bisects the ecological area and proposed scenic reserve. There should be no further disturbance of forest or pakihi vegetation, the shingle pit on the north side of the road should be closed if it is no longer required, fences should be erected on both sides of the road (preferably close to the road), and the cleared areas between these fences and the forest edge should be allowed to regenerate.

The forest and pakihi are on the northern periphery of Ruru block and they are separated from it by a fence, a terrace edge, and in part by two streams. Together the forest and pakihi constitute a very effective and well-buffered conservation unit. Reservation will have practically no impact on farm development.

Any possibility arising of adding additional forest on the eastern edge of the proposed reserve should be favourably considered.

RECOMMENDATIONS

1. THAT r2 (AND THE ADJOINING PAKIHI) BE CREATED A SCENIC RESERVE. (A)
2. THAT A FENCE BE CONSTRUCTED ON THE NORTHERN BOUNDARY OF THE FOREST AND PAKIHI WHEN THE ROAD IS COMPLETED.
3. THAT THE DEPARTMENT LIAISE URGENTLY WITH THE MINISTRY OF WORKS AND THE FOREST SERVICE TO DEVELOP THE SCENIC POTENTIAL OF THE ROAD BEING CONSTRUCTED BETWEEN THE DEEP CREEK ECOLOGICAL RESERVE AND THE PROPOSED SCENIC RESERVE.

r7 (C.S.I. = 68; area = 5.4 ha)

The main features of interest in r7 are the 2.0 ha stand of moderately dense unlogged rimu (B2v) forest on Loopline glacial outwash gravels, and a small group of mountain beech poles and small trees (B5) in the north-east which define the boundary of the Deep Creek beech outlier there. The remainder is principally a hardwood and manuka shrubland which has been logged and at least partly burnt. The forest understorey is grazed, heavily so under the virgin rimu stand.

There are no fences, but there is a drain on the eastern edge.

r7 should be protected after settlement under a conservation covenant. It should be fenced along the forest or shrubland edge, but the small part east of the drain may be excluded if this area is desired for farm development purposes.

RECOMMENDATIONS

1. THAT r7 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT r7 BE FENCED, ALONG THE LINES SHOWN ON FIG. 19.

r8 (C.S.I. = 62; area = 8.1 ha)

r8 occurs on glacial outwash gravels of the Loopline formation. In the west there is a lightly logged B2 association, of moderately dense rimu and miro above a hardwood canopy of kamahi and quintinia. In the east the forest is lower, and contains cedar, pink pine, toatoa and silver pine. This appears to have been more heavily logged, and partly burnt. The forest understorey is extensively grazed in the west but less so in the east. A giant buttressed southern rata tree in the west is one of the few occurrences of this species on the young glacial formations of the Farm Settlement.

There is a fence along the southern ridge of r8, and a track in the south-east corner.

r8 should be protected after settlement under a conservation covenant. Fencing should be along the forest or shrubland edge, except that exclusion of the tall manuka "finger" in the south-east would not significantly detract from the remnant's value. The area within the recommended fenceline is 7.6 ha.

RECOMMENDATIONS

1. THAT r8 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT r8 BE FENCED, ALONG THE LINES SHOWN ON FIG. 19.

r15 (C.S.I. = 75; area = 19.2 ha)

The two special features which contribute primarily to this remnant's high conservation value are the unlogged rimu-cedar (2.9 ha) and kahikatea-rimu (2.0 ha) associations on Loopline glacial outwash gravels. The rimu-cedar (B2v) association is a very dense stand of small rimu and cedar trees, and the kahikatea-rimu (B1v) association a stand of tall kahikatea and rimu. Both understories are still substantially intact. These associations are currently not represented in the reserve systems of North Westland.

The remainder of the remnant includes logged variants of the two associations, and areas of fire-induced (E2) shrublands. These have value in providing comparisons of logged and unlogged forest, and in forming "bridges" between the primary features. The eastern tall manuka (E2) community contains a few kahikatea trees and is beginning to regenerate.

There is a fence along the eastern (Farm Settlement) boundary, and along parts of the northern and southern boundaries. A drain has been cut through the "finger" extension in the south-west.

It is considered that r15 would be best protected after settlement under a conservation covenant, as it is too small for separate reserve status.

Fencing off is essential, and would only require a new fence on the western edge. It would not significantly detract from the remnant's value if the fence were to cut through the E2 shrubland community in the north-west, and if it excluded the cutover rimu-kahikatea forest west of the drain in the south-west corner. The area within this recommended fenceline is 24.3 ha.

This would leave a 2.4 ha area of open shrubby land in the south-east within the fenced area. This could be allowed to regenerate if the cost is such that re-routing the fence here is not warranted.

RECOMMENDATIONS

1. THAT r15 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (B)
2. THAT r15 BE FENCED ALONG ITS WESTERN EDGE, AS SHOWN ON FIG. 19.

r24 (C.S.I. = 71; area = 10.8 ha)

An unlogged B2v community on Loopline outwash gravels, consisting of tall, large diameter, predominantly rimu trees, is the central feature of this remnant. Logged forest associations grading between rimu-dominant (B2) forest on Loopline outwash terrace to podocarp-hardwood (C1) forest on Loopline morainic slopes are also represented. There is dense sapling and pole kahikatea regeneration (B1) on some northern edges. The understorey is grazed heavily under the tall canopy but less so under the lower regenerating canopy.

There is a fence along the southern edge which cuts off a small area in the south-east.

r24 should be protected after settlement under a conservation covenant. Completion of fencing is necessary. The fence (additional to that existing) should follow the shrubland or forest edge, except that exclusion of the tip of the north-eastern "finger" will not significantly detract from the remnant's conservation value.

RECOMMENDATIONS

1. THAT r24 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (C)
2. THAT r24 BE FENCED ALONG ITS NORTHERN, EASTERN AND WESTERN EDGES, AS SHOWN ON FIG. 19.

r34 (C.S.I. = 60; area 2.0 ha)

This is a very attractive dense mixed podocarp stand on Loopline outwash gravels, consisting of recently mature, tall kahikatea and rimu trees (B1 association). There are a few large diameter trees, which suggests the stand may have been only lightly logged, if at all. The understorey has been browsed out by grazing.

There are no fences in the immediate vicinity.

It is recommended that r34 be protected under a conservation covenant, and that it be fenced.

RECOMMENDATIONS

1. THAT r34 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT r34 BE FENCED, AS SHOWN ON FIG. 19.

r37 (C.S.I. = 56; area = 8.9ha)

This area of predominantly podocarp-hardwood (C1) forest on Loopline morainic hill country has been logged, but there are still many tall rimu and miro above the hardwood canopy. There is adequate advanced podocarp regeneration, but the understorey has been heavily grazed.

r37 lies adjacent to r38, proposed for addition to the Bell Hill scenic reserve. It is separated from r38 by a fence and a recently constructed drain. Another fence runs west from this fence through the middle of r37.

r37 has scenic value as it is a prominent skyline feature seen from the Kotuku - Bell Hill Road.

Although r37 is not of high or outstanding conservation value, its addition to the Bell Hill scenic reserve is preferred on account of its size, scenic value and proximity to the reserve. It has lower priority than r38 and r76 , but addition to the scenic reserve and necessary fencing may be more efficiently implemented if done in conjunction with these two remnants.

Fences around the northern, western and southern edges are necessary, joining in the east with fences around r38. Exclusion of the north-west "finger" will not detract significantly from r37's conservation value. The area within the recommended fenceline is 9.1 ha.

Reservation may have some impact on the Farm Settlement. There is a farm track on the eastern edge of r37 which is sometimes used for vehicular access to the paddocks north of r37 and r38. It may be possible to extend tracks from the west to these paddocks, or alternatively to negotiate an easement for continued use of the track in the proposed scenic reserve. The recommended fencing will render redundant the fence through the middle of r37. The recently installed drain on the eastern edge may require occasional clearance if the possible regeneration area in r38 (see Fig. 19) is not accepted, although it would be preferable to let forest regenerate about it.

RECOMMENDATIONS

1. THAT r37 BE ADDED TO THE BELL HILL SCENIC RESERVE. (C)
2. THAT r37 BE FENCED ON ITS NORTHERN, WESTERN AND SOUTHERN EDGES, AS SHOWN ON FIG. 19.

r38 (C.S.I. = 65; area = 33.7 ha)

r38 is a large area of predominantly podocarp-hardwood (C1) forest on Loopline morainic hill country. It has been heavily logged, and tall emergent rimu and miro are now lacking in some parts. There is adequate advanced regeneration, including some dense hardwood pole stands. The forest understorey has been greatly modified by grazing. There is a small area of kanuka dominant shrubland in the southeast.

r38 lies between r37 to the west and the Bell Hill scenic reserve to the south. Its boundaries with these and with freehold land to the east are currently fenced but it is still open to stock from the north. Telephone lines and a part of the former tramway between Ruru and Bell Hill (town) run along the boundary between r38 and the scenic reserve.

The remnant is a skyline feature seen from the Kotuku - Bell Hill Road, and hence has scenic value. It is not as prominent as r37 and, having fewer visible tall podocarps, not as striking.

r38 is clearly worthy of addition to the Bell Hill scenic reserve, on account of both its scenic and conservation values. Reservation of r38 will have the effect of rationalising land use patterns in the vicinity, and of adding to the conservation effectiveness of the reserve. Addition to the reserve and fencing may be more efficiently implemented if done in conjunction with r37 and r76.

Fencing along the northern boundary is essential. The fence should run along the northern edge (including the wet pakihi in the centre) to link up with the current fence between r37 and r38. The precise location of the link-up will depend on the relative cost of fencing around the 1.9 ha open pasture "finger" in the north-west corner against the opportunity cost resulting from letting this area regenerate, considered in relation to fencing around r37 (see Fig. 19). The area within the recommended fenceline is 38.3 ha.

An easement may be necessary for the present telephone line if, in fact, it passes through the proposed addition to the scenic reserve.

Any possibility arising of adding adjoining forest north of the scenic reserve and east of r38 should be favourably considered.

RECOMMENDATIONS

1. THAT r38 BE ADDED TO THE BELL HILL SCENIC RESERVE. (A)
2. THAT r38 BE FENCED ALONG ITS NORTHERN EDGE, AS SHOWN ON FIG. 19.

r40 (C.S.I. = 63; area = 15.0 ha)

r40 is located on a steep Loopline morainic slope, and on the side slopes and bottom of a gully incised by a small creek into the Loopline moraine. The vegetation is primarily regenerating, heavily cutover podocarp-hardwood (C1) forest, but is shrubby in some places (E1 association), especially on edges. There are some kahikatea poles and small trees on the alluvial sediments at the bottom of the gully. The forest understorey has been heavily grazed in places.

A fence runs along parts of the southern and western edges.

r40 should be protected after settlement under a conservation covenant, on account of its size and its regeneration potential. The very elongate shape means fencing it in its entirety is impractical, but certainly the core gully area should be fenced. The fence along the southern boundary could be re-located closer to the forest edge if this is desired for farm development purposes. The total area within the recommended fenceline is 10.4 ha.

RECOMMENDATIONS

1. THAT r40 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT r40 BE FENCED, ALONG THE LINES SHOWN ON FIG. 19.

r44 (C.S.I. = 64; area = 11.5 ha)

r44 is centred on a system of small degradational terraces cut down by a tributary of Molloys Creek into the adjacent Moana glacial outwash terrace. The vegetation (A2 association) is varied, reflecting differences in landform and soils, past logging, and regeneration. There are many kahikatea and matai poles and trees, while cedar, rimu, miro and Halls totara are also present. Podocarp regeneration is plentiful, particularly kahikatea. The forest understorey is generally dense. There is a fairly open area in the south-east, with only a few tall trees and patchy kahikatea sapling and pole regeneration. Some young kahikatea regeneration on the northern edge has recently been cleared.

There is a peripheral fence in the northwest corner.

r44 should be protected after settlement under a conservation covenant. Completion of fencing is important to facilitate vegetation recovery. The fence should follow the forest or shrubland edge, except that exclusion of part of the open shrubland

in the southeast would not significantly detract from r44's conservation values.

RECOMMENDATIONS

1. THAT r44 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT r44 BE FENCED, ALONG THE LINES SHOWN ON FIG. 19.

r47 (C.S.I. = 40; area = 1.7 ha)

This small remnant is recommended for protection because of the coincidental occurrence of a number of special features, and because two of its three sides are already fenced.

r47 is located on a moderately steep north facing morainic slope of the Loopline formation. Forest at this aspect on this formation has been largely cleared elsewhere on the Farm Settlement. The vegetation is regenerating podocarp-hardwood (C1) forest, containing some tall rimu and miro above a hardwood canopy of kamahi, toro, quintinia and other species. It is notable for the abundance of toro and the orange-flowering rata vine, related to its northerly aspect, and for the presence of several southern rata trees and saplings along the top of the ridge. The southern rata trees are one of the few occurrences of this species on the young glacial formations of the Farm Settlement. The forest understorey has been practically eliminated by heavy and prolonged grazing.

The stand, together with several others in the vicinity, is prominently visible from the Kotuku - Bell Hill Road and hence has scenic value.

The completion of fencing along the northern forest edge will assist the recovery of the forest understorey. r47 may then become a vivid demonstration of the effects of heavy and prolonged grazing when compared with other similar stands in the vicinity. It may be the only one to survive in the long-term.

RECOMMENDATIONS

1. THAT r47 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (C)
2. THAT r47 BE FENCED ALONG ITS NORTHERN EDGE, AS SHOWN ON FIG. 19.

r53 (C.S.I. = 56; area = 3.0 ha)

r53 is located on an alluvial degradational terrace incised by a small tributary of Molloys Creek into the adjacent Moana outwash terrace. There are many tall bushy matai trees, but cedar, kahikatea, toatoa and kanuka are also present (A1 association). The lack of tall podocarps of good form suggests the stand has been logged, albeit lightly. The forest understorey has been grazed but is still in good condition. Some manuka shrubland on the northern margins has recently been crushed, exposing the considerable native regeneration which was becoming established underneath it.

There is a fence on the western (Farm Settlement) boundary.

The remnant should be protected after settlement under a conservation covenant. It should be fenced to protect it from grazing, taking advantage of natural topographical features where they occur.

RECOMMENDATIONS

1. THAT r53 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT r53 BE FENCED, ALONG THE LINES SHOWN ON FIG. 19.

r54 (C.S.I. = 70; area = 6.2 ha)

This remnant is located on alluvial terraces within a small basin incised by a tributary of Molloys Creek into the surrounding Moana glacial outwash terrace. It has two valuable features, a beech outlier (A5 association) of eight red beech trees, and a 2.5 ha stand of matai dominant (A1) forest.

The remainder of the vegetation is fire-induced kanuka and manuka (E1) shrubland in which considerable young native regeneration is becoming established. Some gorse within the shrubland area has been sprayed. The very dense undergrowth suggests past grazing has been light, which in part is a result of the natural topographical boundaries of the stand.

There is a fence and a farm track along part of the northern edge.

r54 is of high conservation value but is too small for formal reserve status. Protection under a conservation covenant is therefore recommended. To improve the remnant's long-term viability, as much as possible of the shrubland on both sides of the creek should be included.

It is important that the remnant be fenced and that the fence follow the natural topographical boundaries present. There are steep cliff faces

in some parts which may not require fencing, although the possibility of these acting as a one-way barrier (preferentially keeping stock in rather than out) needs to be borne in mind. As a first approximation, it is suggested that the fence follow the line shown on Fig. 19. The existing fence along the northern edge should be checked to see whether it is adequately stock-proof.

The few gorse shrubs within these boundaries should not be sprayed. They will be suppressed by regenerating native forest within a relatively short time.

The area within the recommended fenceline is 5.6 ha.

RECOMMENDATIONS

1. THAT r54 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (B)
2. THAT r54 BE FENCED ALONG ITS NATURAL TOPOGRAPHICAL BOUNDARIES, AS SHOWN ON FIG. 19.
3. THAT GORSE WITHIN THE FENCED BOUNDARIES BE NOT SPRAYED.

r58 (C.S.I. = 67; area = 14.4 ha[1])

r58 is located primarily on alluvial sediments deposited on the Moana glacial outwash terrace by a small tributary of Molloys Creek (now diverted into a drain). Its two particularly valuable features are a red and mountain beech outlier (A5 and B5 associations) and two areas of kahikatea-matai dominant (A2) forest.

The beech outlier has been much modified in the past and is now in two parts. There are 12 tall red beech and red-mountain hybrid trees alongside the former creek-bed, and there is an isolated group of 14 small mountain beech poles and small trees on the Moana outwash terrace about 100 m west-south-west of the red beech stand. The presence of beech stumps and trunks between these two parts suggests, *inter alia*, that they were formerly contiguous, that the natural extent of beech was considerably larger, and that the distribution of red and mountain beech on alluvial and glacial sediments respectively paralleled that in the Deep Creek beech outlier. An inspection in September 1980 showed that spraying of gorse around the mountain beech stand has caused some mortality of beech foliage and seedlings, and has given the stand an unsightly appearance.

The two kahikatea-matai stands were heavily logged but now show

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1. Area and C.S.I. values are those applicable before the recent shrubland clearance. While the remnant's area is now much reduced, its C.S.I. value is probably not much lower. The lack of an up-to-date map precluded a revision of the index value.

prolific advanced regeneration. Until recently they were interconnected and joined to the red beech stand *via* a 9.6 ha area of dense regenerating kanuka and young kahikatea shrubland. Unfortunately much of this shrubland has been cleared in the course of drain construction over the past two or three years. While the specific features of conservation value have been retained, the effect has been to split the remnant in two and greatly reduce its physical integrity.

There is a fence along the eastern margin of r58, beside the new road. Water from the creeks flowing through r58 has now been diverted into a drain on the northern side.

Consideration of r58's future management and status is made difficult by the isolation of the mountain beech stand, and is compounded by the recent shrubland clearance. The following factors have been taken into account in arriving at the recommendations below:

- nature conservation is a valid land use, and other uses should not be given a higher priority as of right in the allocation of resources;
- much potentially valuable kanuka and regenerating kahikatea shrubland in the vicinity has recently been cleared and converted to pasture;
- r58 is now much too small for formal reserve status;
- most of r58's conservation values are represented in the *western* sector;
- the mountain beech stand is equally important to the interpretation of the beech outlier;
- restoration of the beech outlier to a semi-natural condition and size is desirable for scientific purposes and for its long-term viability; and
- beech and kahikatea forest will regenerate rapidly (within 80-100 years) if protected from fire and grazing.

It is therefore recommended that the *western* sector of r58 be protected after settlement under a conservation covenant, and that it be fenced along the boundaries shown on Fig. 19. These boundaries have the effect of including many of the now isolated small groups of trees on the northern boundary, and providing for renewed kahikatea regeneration there; of including the mountain beech outlier; and of

providing an area between the red and mountain beech stands to allow the beech species to expand to something approaching their former distribution (in as much as it is known). The area within the recommended fenceline is 6.9 ha.

A 1.7 ha area of open land is therefore included which is specifically requested for nature conservation purposes in preference to pasture development. To encourage regeneration and improve the aesthetic appearance of the stand, planting of beech and kahikatea seedlings within the fenced area could be considered, using seed from the vicinity.

RECOMMENDATIONS

1. THAT THE WESTERN SECTOR OF r58 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (B)
2. THAT r58 BE FENCED ALONG THE LINES SHOWN ON FIG. 19.

r65 (C.S.I. = 63; area = 57.0 ha)

r65 occurs on slightly dissected morainic hill country of the Loopline formation. Its principal conservation values are its large size and the possible presence of kiwis (see Appendix 4).

The vegetation is principally heavily cutover podocarp-hardwood (C1) forest, most of it logged within the last 20-30 years. There is a diversity of canopy hardwood species. Podocarp and hardwood regeneration are generally adequate for stand recovery. The forest understorey is heavily grazed on the northern periphery but is much less modified in the interior.

There are fences along the southern (Farm Settlement) and eastern boundaries, plus an intruding one in the west.

Although r65 is of substantial size, it presently has neither specific conservation nor scenic values which would merit reserve status. Two options appear to be suitable. The stand could be protected after settlement under a conservation covenant, or it could be retained as Crown land and managed as a reserve for scenic or other purposes under section 38 of the Reserves Act 1977. However, upgrading to formal scenic reserve could be considered if the presence of kiwis is confirmed and/or the new road on the south part of Ruru block is extended around the eastern edges towards the Moana - Rotomanu Road.

The possible presence of kiwis has important management implications.

The report requires confirmation, but until then it would be prudent to assume they are present. The remnant should be fenced off to protect it from stock grazing *as a matter of urgency*, and any possum control operations should aim to minimise effects on ground-dwelling birds (see section 4.1.3.9).

Completion of fencing requires only a fence along the northern edge (see Fig. 19). Exclusion of the eastern " finger" will not significantly detract from the remnant's conservation value. It is to an extent compensated by the inclusion of a shrubland area in the south which is slowly beginning to regenerate (and which is practically inaccessible for present farm development). The area within the recommended fenceline is 54.5 ha.

The fencing pattern recommended has the effect of rendering redundant a small length of the intruding fence in the west.

Any possibility arising of adding adjoining forest on the south-west edge should be favourably considered.

RECOMMENDATIONS

1. THAT r65 BE PROTECTED AFTER SETTLEMENT EITHER BY:
   A. INCLUSION WITHIN A CONSERVATION COVENANT; OR
   B. RETENTION AS CROWN LAND AND MANAGEMENT AS A RESERVE FOR SCENIC AND OTHER PURPOSES.
2. THAT UPGRADING TO SCENIC RESERVE STATUS BE CONSIDERED IF THE PRESENCE OF KIWIS IS CONFIRMED AND/OR THE NEW RURU ROAD IS EXTENDED AROUND THE EASTERN EDGES TO THE MOANA - ROTOMANU ROAD.
3. THAT r65 BE FENCED ALONG ITS NORTHERN EDGE, ALONG THE LINES SHOWN ON FIG. 19.
4. THAT UNTIL THE PRESENCE OF KIWIS IS PROVED OR DISPROVED, ANY POSSUM CONTROL OPERATIONS SHOULD AIM TO MINIMISE EFFECTS ON GROUND-DWELLING BIRDS.

r76 (C.S.I. = 83; area = 47.6 ha)

r76 has one of the highest conservation values of any forest remnant on the Farm Settlement. It is located primarily on a ridge and slopes of the Loopline morainic formation, but there is also a poorly drained terrace in the south-east. Most of the vegetation is podocarp-hardwood (C1) forest which was logged many years ago but which has regenerated very well. There are still many tall rimu, miro and kahikatea emergent above the hardwood canopy. A small area (5.9 ha) of similar forest (C1v) has been only lightly logged, if at all. The kahikatea-rimu (B1) forest on the swampy terrace in the south-east was heavily logged about 20 or more years ago. Regeneration there is inhibited by the high water table. The whole remnant has been fenced off for many years, so the forest understorey is in good condition. r76 has a high forest bird species richness (12 species) and the S.I. fernbird is present in the open swampy ground in the south-east.

This remnant is recommended for addition to the Bell Hill scenic reserve. The boundary should follow the present fenceline (see Fig. 19). Early implementation of this recommendation is preferred, but it may be more efficiently done in conjunction with r37 and r38.

r76 is adjacent to the Bell Hill scenic reserve and is not distinguishable from it on its conservation or scenic values. Together the scenic reserve and its three proposed additions (r37, r38, r76) constitute a large (168 ha) and valuable representation of forest on Loopline morainic hill country in North Westland. Their conservation effectiveness is enhanced by their continuity with the substantial block of hill country forest (Otira-Kopara S.F. 25) to the east. The Department should liaise with the Forest Service to ensure that management of the State Forest is in sympathy with the values of the scenic reserve and its proposed additions.

Reservation may be expected to have no impact on farm development.

RECOMMENDATION

1. THAT r76 BE ADDED TO THE BELL HILL SCENIC RESERVE. (A)

r78 (C.S.I. = 71; area = 43.5 ha)

This substantial forest remnant is centred on a deep gully incised by a small creek into the adjacent Loopline morainic hill country. The gully opens on to the Moana outwash terrace in the south-west. The vegetation is predominantly heavily cutover podocarp-hardwood (C1) forest. Some miro, rimu and a few kahikatea remain, emergent above a fairly dense hardwood canopy. There is considerable advanced rimu and kahikatea regeneration. The forest understorey has been extensively grazed about unfenced edges, but is in better condition in the interior. There is a small group of southern rata trees in the centre, at the top of the ridge on the south side of the creek.

Currently r78 is fenced along its eastern, northern and western edges. A farm road cuts through its south-western extremity.

It is recommended that r78 be protected after settlement under a conservation covenant. The southern edge should be fenced, except that exclusion of part of the south-east "finger" will not significantly detract from r78's conservation value. The area within the recommended fenceline is 47.0 ha.

This recommendation has the effect of including two small open areas within the fenceline. Both of these have natural values which justify their inclusion. The one in the west (1.8 ha) is already covered by shrub vegetation, and it may be expected to quickly return to high forest. The other (2.6 ha) is on a small swampy terrace, and is covered by mosses, *Juncus* spp., ground ferns, other herbaceous plants, and occasional shrubs. The area is potentially useful in representing pakihi vegetation, as the wet sub-surface conditions appear to be inhibiting forest regeneration. Neither of these areas is particularly accessible for pasture development, and inclusion within the protected area is unlikely to have any significant impact on farm development.

RECOMMENDATIONS

1. THAT r78 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (C)
2. THAT r78 BE FENCED ALONG ITS SOUTHERN EDGE, AS SHOWN ON FIG. 19.

r80 (C.S.I. = 54; area = 14.4 ha)

r80 occurs on a ridge and slopes of the Loopline morainic hill country formation, grading in the south onto the Moana glacial outwash terrace. In its podocarp-hardwood (C1) forest, there are many tall miro, rimu and a few kahikatea emergent above the canopy of kamahi, quintinia and other hardwoods. Advanced rimu and kahikatea regeneration is plentiful in places. The forest understorey is heavily grazed about the northern edges but is in better condition elsewhere.

Currently there are fences on the western and southern boundaries.

RECOMMENDATIONS

1. THAT r80 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT r80 BE FENCED ALONG ITS NORTHERN AND EASTERN BOUNDARIES, AS SHOWN ON FIG. 19.

r81 (C.S.I. = 59; area = 12.5 ha)

This remnant is located primarily on glacial outwash gravels of the Moana formation. A small tributary of Molloys Creek meandering through the stand has planed down part of the surface and incised itself into a gully. The vegetation (B1 association) is variable. There are scattered pole and small tree size rimu, kahikatea, miro and cedar, among toatoa, kamahi, wineberry and other hardwoods. Kahikatea sapling and pole regeneration is plentiful in some places. Grazing appears to have been light, for the forest understorey is generally dense.

A logging track and hauler lines indicate the stand was heavily logged (or re-logged) about 20 or so years ago. There are fire-induced manuka dominant shrublands around much of the periphery. Such modification makes the stand aesthetically unappealing at present, but the regeneration evident will undoubtedly ensure a rapid recovery and restoration to an attractive state.

The stand has a potential scenic value if and when the adjoining new road on the south part of Ruru block is extended and opened to public traffic.

There is a fence on the western edge, adjacent to the road.

r81 should be protected after settlement under a conservation covenant. It should be fenced along the forest or shrubland edge, except

that exclusion of the predominantly manuka shrubland "finger" in the south-east will not significantly detract from the stand's conservation values. The area within the recommended fenceline is 12.9 ha.

To provide a satisfactory boundary, a small semi-open area is included within the recommended fenceline (Fig. 19).

Because of r81's potential scenic value, its recommendations are assigned a higher priority than would be merited on conservation value alone.

RECOMMENDATIONS

1. THAT r81 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (C)
2. THAT r81 BE FENCED, ALONG THE LINES SHOWN ON FIG. 19.

r94 (C.S.I. = 54; area = 13.7 ha)

r94 is located on rolling Moana morainic slopes. Its podocarp-hardwood (C1) forest has been logged, heavily in the north. Nevertheless there are still a number of tall rimu and miro emergent above the hardwood canopy, and there is considerable advanced rimu and kahikatea regeneration. Semi-overgrown logging tracks suggest this remnant was logged (or re-logged) about 20 or more years ago. The forest understorey has been heavily grazed.

The Bell Hill Road is immediately adjacent on the eastern side, giving r94 considerable scenic value. An appealing avenue effect is created where trees from r94 and the Otira - Kopara State Forest to the east almost overlap above the road.

There are fences on the eastern (Farm Settlement) and northern boundaries.

r94 should be protected after settlement under a conservation covenant. It should be fenced along its western and southwestern boundaries, as shown on Fig. 19. The area within the recommended fenceline is 15.7 ha.

A 1.4 ha area of swampy pakihi is included within the recommended fenceline. This has the advantages of providing a satisfactory boundary and of including pakihi vegetation of conservation value. The opportunity cost to farm development is likely to be minimal as the area would require considerable fencing and drainage.

Because of r94's scenic values, its recommendations are assigned a higher priority than would be merited on conservation value alone.

RECOMMENDATIONS

1. THAT r94 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (C)
2. THAT r94 BE FENCED ALONG ITS WESTERN AND SOUTHWESTERN BOUNDARIES, AS SHOWN ON FIG. 19.

r97 (C.S.I. = 55; area = 0.7 ha)
r102 (C.S.I. = 71; area = 6.9 ha)
r103 (C.S.I. = 70; area = 7.1 ha)

These three scientifically valuable forest remnants are the remains of a single red and mountain beech outlier, and are therefore considered together.

The three remnants are located on rolling morainic ridges and slopes of the Moana formation. The beech forest has been much modified by past burning and, to a lesser extent, by logging of podocarps. Charred beech stumps and trunks between the three remnants indicate the beech occurrences were formerly contiguous and that the outlier was considerably larger than now. Stands of tall, large diameter red beech, plus infrequent rimu, miro, mountain beech, kahikatea and subcanopy kamahi, occur in all three remnants (B6 association). There are also extensive areas of dense fire-induced sapling and pole regeneration in which mountain beech is usually dominant. Both beech species are expanding into peripheral manuka-dominant shrublands. Generally the forest understorey has been heavily grazed.

Additionally there are non-beech associations in all three remnants. Manuka-dominant shrubland margins occur in r97 (not mapped) and in r102. In r103 there are areas of logged but regenerating podocarp-hardwood (C1) forest, and of heavily logged kahikatea-rimu forest (B1) forest in which there is profuse sapling and pole kahikatea regeneration. The presence in r103 of a beech-podocarp boundary which has only been modified by light logging adds to the scientific value of the stand.

All three remnants should be protected after settlement under a conservation covenant. They should be fenced, along the lines shown on

Fig. 19. Small parts of the E2 and B1 communities in r102 and r103 are excluded to minimise the need for additional fencing.

Although advantage of existing fences has been taken where possible, some lengths are rendered redundant under the recommended arrangement. Some shrubland areas are included within the fencelines, but these may be expected to be replaced by regenerating beech within a relatively short time. The small gorse patches within these areas should not be sprayed once fencing is complete.

To protect the integrity of the remnants (particularly the smallest, r97), it is important that the recommended fencelines be adhered to.

Unlike r58, inclusion of open semi-developed pasture land with a view to restoring the links between the three remnants does not appear justified. The three present remnants are sufficiently large to be reasonably confident of their future. Moreover, a not inconsiderable area would be required.

RECOMMENDATIONS

1. THAT r97, r102 AND r103 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (B)
2. THAT r97, r102 AND r103 BE FENCED, ALONG THE LINES SHOWN ON FIG. 19.

r105 (C.S.I. = 71; area = 23.2 ha)

r105 is located on glacial outwash gravels of the Moana formation, and on slightly lower alluvial sediments deposited by a small tributary of Molloys Creek. Variations in landform and in past modification have resulted in a varied vegetation. The feature of highest value is a dense stand of tall, thin rimu (B2 association) in good condition despite grazing and logging of the larger podocarps. Areas of once similar forest immediately adjacent were very heavily logged and now support only low podocarp and hardwood regeneration of varying density. On the alluvial sediments are areas of former matai (A1) and mixed podocarp (A4) forest which were also heavily logged and partly burnt. Generally forest understorey condition varies inversely with canopy density.

There are no fences in the vicinity of r105, but a farm track on the edge of the glacial outwash terrace runs through its entire length.

The following factors have been taken into account in arriving at

the recommendations below:

- r105's long but narrow rectangular shape, which would require a large length of fencing;
- the concentration of conservation values in the centre and western sector; and
- probable rapid forest regeneration under the shrubby A4 association once protected from grazing.

It is recommended that the central and eastern sectors be protected after settlement under a conservation covenant. They should be fenced, along the lines shown on Fig. 19. The area within the recommended fence-line is 15.5 ha.

Gates will be necessary at both ends if the farm track is needed for continued farm access.

RECOMMENDATIONS

1. THAT THE EASTERN AND CENTRAL SECTORS OF r105 BE PROTECTED AFTER SETTLEMENT UNDER A CONSERVATION COVENANT. (D)
2. THAT THE EASTERN AND CENTRAL SECTORS OF r105 BE FENCED, ALONG THE LINES SHOWN ON FIG. 19.

4.2.4.2 Deep Creek Pakihi. The Deep Creek pakihi is a 9.3 ha area of fire-induced pakihi in the far north-east of Rūru block (see Fig. 19 for its location and section 2.5.4.2 for a description).

The pakihi has considerable natural value. It is the only remaining substantial area of well-established pakihi on the Farm Settlement. It will acquire increasing scarcity value as pakihis elsewhere in North Westland are converted to pasture or exotic forest. The pakihi supports an apparently rare New Zealand moss (*Sphagnum subnitens*), and the largest concentration of S.I. fernbirds recorded on the Farm Settlement.

The Department of Lands and Survey has long been seeking an area of pakihi, typical of that present before it acquired the Farm Settlement, as a reference site to demonstrate its achievements in pakihi farm development. The Deep Creek pakihi has many features which would make it eminently suitable for this purpose. The land is typical of that being developed by the Department. It has long been isolated from the rest of the Farm Settlement by Deep Creek and its riparian forest vegetation so side-effects from farm operations such as aerial topdressing are likely to have been

minimal. The recently constructed county road on the pakihi's northern edge and the new bridge across Deep Creek will, however, make it readily accessible to the general public.

The pakihi's future status must also be evaluated in relation to the surrounding land. To the north it is bounded by the Deep Creek ecological area in Mawhera State Forest. To the south, east and west, it is completely enclosed by forest remnant r2, the highest ranked remnant on the Farm Settlement and already recommended for scenic reserve status (section 4.2.4.1).

The pakihi has a rather unsightly appearance which has been aggravated by recent earthworks for the new road on its northern edge. However, the most appropriate future status for the pakihi which recognises its natural values, its potential as a reference site for pakihi farm development, and its relationship to the surrounding land, is considered to be incorporation within the proposed scenic reserve. Reservation of a pakihi may challenge previous concepts of what a reserve should be, but it is well within the scope of a reserve system which seeks to represent the full range of landforms and biota within a region. It will also provide the Department with a golden opportunity to explain to the public the history of pakihi farm development at Bell Hill within a particularly appropriate context, the integration of such development with nature conservation.

RECOMMENDATION

1. THAT THE DEEP CREEK PAKIHI BE INCORPORATED WITHIN THE SCENIC RESERVE PROPOSED FOR r2. (A)

4.2.4.3 Maria's Mire. Maria's Mire (area = 5.0 ha) is a large peat swamp adjacent to the Kotuku - Bell Hill Road (see Fig. 19 for its location and section 2.5.4.1 for a brief description).

Maria's Mire is one of several Aranuian (post-glacial) peat accumulations in North Westland which were analysed by Moar (1971) for historical pollen. These analyses are the basis of present scientific understanding of Aranuian vegetation development in the region. Maria's Mire is therefore an important scientific reference site and should be protected.

In considering recommendations, a distinction needs to be drawn between surface and subsurface features. On the surface, the natural vegetation has been irreparably modified by burning. Grazing and other surface activities may therefore be continued, provided their effects do not extend below the surface. If deep pugging by cattle occurs, however, it would be preferable to have only sheep grazing the surrounding paddock.

The principal value of Maria's Mire lies in the pollen record in the five metres of peat and other sediments below the surface. The main threats to this are swamp drainage, peat mining, or other subsurface activities. Peat is destroyed when water protecting it from oxidation is removed, so it is imperative that Maria's Mire be *not* drained.[1] Peat mining directly destroys the pollen record, but it is unlikely in the immediately foreseeable future as the quantity of peat in Maria's Mire is small. The danger of casual extraction for horticultural purposes remains.

It is therefore recommended that there be appropriate designation in the farm Management Plan (for the development period) and in a conservation covenant (after settlement) to protect Maria's Mire from swamp drainage, peat mining, or other deleterious subsurface modification.

RECOMMENDATION

1. THAT THERE BE APPROPRIATE DESIGNATION IN THE FARM MANAGEMENT PLAN AND IN A POST-SETTLEMENT CONSERVATION COVENANT TO PROTECT MARIA'S MIRE FROM SWAMP DRAINAGE, PEAT MINING, OR OTHER SUB-SURFACE MODIFICATION. (B)

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1. Already the outlet to Molloys Creek has been slightly enlarged, and the water-table has probably been lowered as a consequence.

4.2.5 Other Forest Areas

Tentative recommendations are also made for three other forest areas which were not covered in the same degree of detail as others during the present survey. The three areas are all peripheral to the Farm Settlement.

Part Rural Section (R.S.) 2900 (Area = 17 ha)

In the context of rationalising tenure patterns of forested Crown land in the vicinity of the Bell Hill scenic reserve (see r76), consideration should be given to adding to the reserve the forested part of R.S. 2900 east of the Bell Hill Road. The area may be expected to have similar conservation and scenic values to the land already in the reserve and in the additions proposed in this report (r37, r38, r76). The boundary between forest and the pasture of the Farm Settlement is already fenced.

RECOMMENDATION

1. THAT CONSIDERATION BE GIVEN TO ADDING THE FORESTED PART OF RURAL SECTION 2900 EAST OF THE BELL HILL ROAD TO THE BELL HILL SCENIC RESERVE.

Part Rural Section (R.S.) 2899 (Area = 128 ha)

The south-east part of R.S. 2899, lying north of Kangaroo Lake and east of the Otira-Kopara S.F. 25 outlier, is currently excluded from the developed part of Ruru block.

The area lies on Moana formation morainic hill country. The vegetation is predominantly heavily cutover podocarp-hardwood forest, and contains considerable gorse on old logging tracks. There is a small red beech outlier, at S52:051706 . The area provides a natural forest backdrop to Kangaroo Lake, and hence has considerable amenity value.

This part of R.S. 2899 should be included within the scope of current discussions between the Department of Lands and Survey and New Zealand Forest Service on rationalising land tenure in the vicinity of the Lady Lake scenic reserve and the Lady Lake amenity area in Otira-Kopara S.F. 25. For the protection of conservation values, the preferred tenure for Lady and Kangaroo Lakes and the adjacent forest is scenic reserve. Scenic reserve status would also recognise the scenic and

recreational significance of the area.

RECOMMENDATION

1. THAT CONSIDERATION BE GIVEN FOR INCLUDING THE SOUTH-EASTERN PART OF RURAL SECTION 2899 IN AN EXTENDED LADY LAKE SCENIC RESERVE.

Rural Sections 2744, 4168 and 4899 (Area ≐ 112 ha)

This area near the Kaimata dam was acquired by the Department of Lands and Survey with the area added to Blairs block in 1979. It will probably be considered for disposal. About one-third is still forested.

The beech-podocarp forest is situated on Loopline outwash terrace gravels, and on a steep slope between outwash terraces of the Loopline and Moana formations. The former beech-podocarp forest has been logged for its podocarps. It now consists mainly of red and mountain beech, plus a few podocarps and a hardwood subcanopy. There is adequate advanced regeneration for stand recovery. The beech forest here defines the limit of upstream beech migration in the Arnold River valley. It also has an amenity value related to its contiguity with the Arnold valley and Kaimata dam roads, although this has been reduced by recent partial clearance adjacent to the former road.

It would be desirable to retain the present forest cover. This could be achieved by the Department negotiating a conservation covenant with the new owner, or by registering a caveat on the land title preventing the clearance of forest.

RECOMMENDATION

1. THAT THE DEPARTMENT OF LANDS AND SURVEY SEEK TO PROTECT THE FOREST COVER ON THE KAIMATA BLOCK.

4.2.6 Avifauna

The bird species on the Farm Settlement of principal relevance to nature conservation are the native, forest dwelling birds, the S.I. fernbird and the Australian little grebe.

The future of the remaining forest bird species is intimately associated with the future of their habitat, the forest remnants. Provided that the remnants are protected by implementation of the recommendations in this report (sections 4.2.2, 4.2.3.1 and 4.2.4.1), forest bird populations may be expected to be maintained or even improved as regeneration proceeds. Care however needs to be exercised in possum control operations to minimise risks to vulnerable non-target species such as kiwi and weka (section 4.1.3.9).

The future of the S.I. fernbird is less secure. Conversion of fernbird shrubland habitat to pasture during farm development inevitably results in the loss of most of the population that may have been present. Two places where there are small concentrations of fernbirds, in the Deep Creek pakihi and in swampy vegetation between forest remnants b4, b5 and b6, have been recommended for some form of protection (sections 4.2.2.1 and 4.2.4.2). However the small number of birds at both sites and the likely successional return of the present vegetation to forest renders these populations vulnerable to extinction in the long term.

The Australian little grebe has been recorded during two recent summers on the large pond south-west of Rutters cottage on Ruru block (see section 2.6.3.3(b) and Fig.19).Although expanding its range, the little grebe is still a very rare species in New Zealand. It is strictly protected. Shooters requesting permission to shoot waterfowl on the Ruru pond during the game season should be informed of the presence, rarity and strictly protected status of the little grebe.

RECOMMENDATION

1. THAT GAME SHOOTERS REQUESTING THE USE OF THE RURU BLOCK POND ON WHICH THE AUSTRALIAN LITTLE GREBE IS PRESENT BE INFORMED OF ITS PRESENCE, RARITY AND STRICTLY PROTECTED STATUS.

4.2.7 Synopsis of Recommendations

Table 7 summarises the following salient features of each remnant or other natural feature for which a recommendation is made: recommended status; priority for any necessary management protection measures; conservation status index; area (area within recommended fenceline if this is different from forest remnant area *per se*); and approximate length of fencing required.

TABLE 7: Synopsis of Recommendations on Forest Remnants and other Natural Features on Bell Hill Farm Settlement.

Abbreviations and Symbols Used

SR	:	Establishment of scenic reserve
aSR	:	Addition to existing scenic reserve
CLRFS	:	Crown land reserved from sale
CC	:	Conservation covenant
CL	:	Crown land (and management as a reserve for scenic or other purposes)
AZ	:	Amenity Zone (in State forest)
RZ	:	Riparian Zone (in State forest)
A,B,C or D:		Denotes priority assigned to management protection measures
pt	:	Part
*	:	Denotes area within recommended fenceline is different from forest remnant area *per se*.

BLAIRS BLOCK

Remnant	Recommended Status	Conservation Status Index	Area (ha)	Length of Fencing (m)
Priority A				
b28	aSR	84	54.9	1050
b29	aSR	69	23.4	nil
Priority B				
b7)) b8)	CC	65 / 75	11.0)) 6.5)	2450
b10)) b30)	CC or CL	67 / 71	31.9)) 69.5)	2630
b19	CC	45	0.4	190
b20	CC	64	22.2	1580
Priority C				
b4)) b5)) b6)	CC	68)) 45)) 45)	28.7*	1790
pt b16	CC	66	7.0	nil
b22	CC or CL	56	5.2	620
b32	CC or CL	69	55	2120
Priority D				
b1	CC	64	10.7	930
b13	CC	62	8.2	1150
Transfer to Mawhera State Forest				
b3	-	82	37.5	nil
pt b16	AZ	66	12.5	nil
b17	AZ	81	42.0	nil
Total (Blairs Block)			425.6[1]	14510[2]

1. The 112 ha Kaimata block, for which retention of forest cover after re-sale is recommended, is excluded from this subtotal.

2. An additional 700 m is needed to complete fencing between the Arnold River I scenic reserve and Blairs block.

WEKA BLOCK

Remnant	Recommended Status	Conservation Status Index	Area (ha)	Length of Fencing (m)
Priority A				
w40)) w41)	SR	69	44.6*	470
		84	39.6*	nil
Priority B				
w4)) w5)) w12)	CL	68)) 64)) 58)	65.7*	nil
w18	CLRFS	51	5.8*	nil
w19)) w34)) w37)	CLRFS or RZ	75 74 70	86.7*	nil
w32)) w38)	AZ or CL or CC	81 69	32.1* 5.6	1240 360
w58	CC	45	1.2*	480
Nan's Kettle	CC	-	1.3	-
Priority C				
w13	CC	58	5.8*	680
Priority D				
w33	CC	65	26.8*	2400
Total (Weka Block)			315.2	5630

RURU BLOCK

Remnant	Recomended Status	Conservation Status Index	Area (ha)	Length of Fencing (m)
Priority A				
r2	SR	93	61.0	1050
r38	aSR	65	38.3*	830
r76	aSR	83	47.6	nil
Deep Creek Pakihi	SR	-	9.3	-
Priority B				
r1	CLRFS	63	8.2*	nil
r15	CC	75	24.3*	950
r54	CC	70	5.6*	760
r58	CC	67	6.9*	1210
r65	CL or CC	63	54.5*	1880
r97	CC	55	0.7	250
r102	CC	71	6.9	1220
r103	CC	70	7.1	690
Maria's Mire	CC	-	5.0	-
Priority C				
r24	CC	71	10.8	1250
r37	aSR	56	9.1*	880
r47	CC	40	1.7	170
r78	CC	71	47.0*	1220
r81	CC	59	12.9*	1420
r94	CC	54	15.7*	970
Priority D				
r7	CC	68	5.4	900
r8	CC	62	7.6*	870
r34	CC	60	2.0	620
r40	CC	63	10.4*	960
r44	CC	64	11.5	1510
r53	CC	56	3.0	900
r80	CC	54	14.4	850
r105	CC	71	15.5*	1900
Total (Ruru Block)			442.4[1]	23 260 m

1. The proposed addition in section 4.2.5 of part R.S. 2900 (17 ha) to the Bell Hill scenic reserve, and of R.S. 2899 (128 ha) to an extended Lady Lake scenic reserve, is not included in this sub-total.

CHAPTER FIVE

CONCLUSION

This study documents the land and biological resources of the Bell Hill Farm Settlement that are important to assessing land use suitability for nature conservation. Landform, vegetation and the degree of its modification, avifauna and other features of 204 forest remnants are inventoried. The nature conservation value of each remnant is assessed and ranked objectively using a numerical index based on four ecological criteria. General recommendations are formulated for the protection of natural features on farm development blocks within a multiple objective land use framework. Specific recommendations are made for the protection on the Bell Hill Farm Settlement of 59 forest remnants, two peat swamps and an induced pakihi.

The survey and evaluation system used in this study is designed for rapid inventory of a large number of forest remnants or other natural features, and assessment of their conservation value. Uniformity, simplicity and speed are its chief advantages, and are vital characteristics given the limited resources currently available for biological surveys, the shortages of available time under pressures of development, and the vast range of natural features still to be surveyed in such regions. Although it may be the only feasible method under such constraints, broad scale survey and ranking can of course only indicate in general terms the relative nature conservation values. The assumption that plant and avifaunal communities are *the* determinant of nature conservation value will not always hold, and more detailed ecological surveys may challenge initial conclusions. Other weaknesses such as the under-valuing of some characteristics of a natural feature (section 4.2.1.1.) should be apparent in any study more thorough than a primary survey and can be readily compensated for when framing recommendations.

The Department of Lands and Survey is New Zealand's largest single farming enterprise. Generally the land it is bringing into farming is marginal country which is less than completely modified and which may still retain natural features of considerable conservation value. Farm development blocks throughout New Zealand may be able to contribute

significantly to a national nature conservation programme such as suggested by Molloy *et al.* (1980). It is to be hoped that the Department of Lands and Survey will, in the better integration of its dual land development and conservation functions, develop a policy and programme to protect natural features of conservation value on its farm development blocks. The methodology developed in this study, which is itself modelled on Park and Wall (1978), can be used on other development blocks with only minor modifications occasioned by local scale and ecology. The study, encompassing methods for inventorying forest remnants and other natural features together with general recommendations (section 4.1) for their protection during and after farm development, is offered as a working model for nature conservation capability assessment on all the Department's development blocks in New Zealand.

ACKNOWLEDGEMENTS

Many people have directly and indirectly contributed to this study. To all of them, including any unintentionally not listed, I express my unreserved thanks.

My supervisor, Professor Kevin O'Connor, Professor of Range Management in the Joint Centre for Environmental Sciences, Lincoln College, provided the encouragement and facilities to set up and develop the study, and guided its development while yet holding a welcome loose rein on its progress. He also critically read the manuscript.

Officers of the Department of Lands and Survey, Westland, offered their largest development project as the subject of the study. Messrs Bob Austin (District Fields Officer), Earl Cameron (Senior Fields Officer), and Doug Benbow, Don Turner and Treva Pinn (Farm Managers) allowed me free run on the Farm Settlement and provided maps and aerial photographs, on-site accommodation and assistance with transport during six months of field work. Their co-operation and support is gratefully acknowledged.

Dr Gavin Daly and Mr Gerry McSweeney have, in numerous field trips and other ways, freely given of their time and knowledge to facilitate and stimulate my understanding of West Coast forests and culture. Gerry was also instrumental in arranging the subject of the study.

Selwyn June assisted with his knowledge of North Westland forests. He, Colin O'Donnell and David Alexander also read parts of the manuscript.

Mr Terry Heiler provided the planimeter and instructed in its use.

Dr Andrew Dobson assisted in the identification of many of the pakihi plants. Professor J.D. Lovis and Patrick Brownsey assisted in identification of ferns.

Dr Noel Hellyer, Geoff Mew, Eric Spurr, Keith Owen and Jo Douglas provided unpublished information and material.

Graeme Loh, Shannel Courtney and Janetta Overmars provided company for periods in the field. Graeme and Shannel also assisted with plant identification. Ray Ford assisted with geological interpretation, and Stewart Lauder with observations on the Australian little grebes.

My family, friends and flatmates (past and present) supported and encouraged me over the duration of the study, including an interlude of prolonged illness.

Mrs Olga Cattanach and Mrs Judith Mackenzie skillfully and patiently typed this manuscript. Pat Prendergast prepared the diagrams and maps in similar fashion.

Field work towards this project was in part carried out under the Temporary Employment Programme of the Department of Labour. The cartographic assistance of the Department of Lands and Survey is also acknowledged.

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APPENDIX 1: Plant Species of Deep Creek Pakihi

(i) Lichens and Mosses

Campylopys cf. *bicolor*
Polytrichum commune
Sphagnum cristatum
S. subnitens

(ii) Ferns and Fern Allies

Blechnum minus
B. penna-marina
Dicksonia squarrosa
Gleichenia circinata
Histiopteris incisa
Hypolepis sp.
Paesia scaberula
Polystichum vestitum
Pteridium aquilinum var. *esculentum* (bracken)

(iii) Gymnosperms and Angiosperms

Archeria traversii
**Agrostis tenuis* (browntop)
Baumea tenax
Carex virgata
Centella uniflora
Coprosma cf. *parviflora*
C. tenuicaulis
Cortaderia richardii
Cyathodes empetrifolia
+Dacrydium cupressinum (rimu)
Elaeocarpus dentatus (hinau)
Gahnia rigida
Gaultheria x *Pernettya* (integeneric hybrid)
Griselinia littoralis
Haloragis sp.
Hydrocotyle sp.

Hypochoeris radicata
Juncus canadensis
J. gregiflorus
J. planifolius
Leptospermum scoparium (manuka)
**Lotus pedunculatus*
Luzuriaga parviflora
Myrsine divaricata
Neomyrtus pedunculata
Nertera depressa
Notodanthonia sp.
Phyllocladus alpinus (toatoa)
**Plantago* sp.
Podocarpus acutifolius
+*Podocarpus dacrydioides*
Pratia angulata
Rubus australis
R. squarrosus
Ulex europaeus (gorse)
Weinmannia racemosa (kamahi)

NOTE: * = adventive species
+ = species occurring only as seedlings

APPENDIX 2: Plant Species of Forest Remnant Communities

For each plant community this Appendix lists:

(a) the species typically found in the community; and

(b) all the forest remnants containing examples of the community.

The species lists are by no means complete. They are based mainly on winter field work so few annual species are included. Not all plants were identified to species level:

Common names are cited at first occurrence only.

NOTE: * = adventive species

pt = part

pts = parts

A1. Matai dominant, plus cedar and hardwoods

(i) Trees and Tall Shrubs

Carpodetus serratus (putaputaweta, marbleleaf)
Dacrydium biforme (pink pine)
D. colensoi (silver pine)
Griselinia littoralis (broadleaf)
Leptospermum ericoides (kanuka)
Libocedrus bidwillii (cedar)
Phyllocladus alpinus (toatoa)
Podocarpus acutifolius
P. dacrydioides (kahikatea, white pine)
P. hallii (Halls totara)
P. spicatus (matai, black pine)
Weinmannia racemosa (kamahi)

(ii) Shrubs

Aristotelia fructicosa
Coprosma foetidissima
C. rhamnoides
C. rotundifolia
C. tenuicaulis
Elaeocarpus hookerianus (pokaka)
Gaultheria antipoda
Hebe salicifolia
Hoheria glabrata
Leptospermum scoparium (manuka)
Melicope simplex
Myrsine divaricata
Neomyrtus pedunculata (rohutu)
Olearia avicenniaefolia
Pseudopanax anomalum
P. crassifolium (horoeka, lancewood)
Pseudowintera colorata (horopito, pepper tree)

(iii) Lianes and Scramblers

Muehlenbeckia sp.
Rubus australis
R. cissoides

*R. *fructicosus* (blackberry)
R. schimedlioides

(iv) Ground Cover and Epiphtes

Acaena sp.
Gahnia sp.
Juncus sp.
Luzuriaga parviflora
Microlaena avenacea (bush rice grass)
**Prunella vulgaris*
**Ranunculus repens*
**Senecio jacobaea* (ragwort)

(v) Ferns and Fern Allies

Asplenium flaccidum
A. terrestre
Blechnum capense
B. fluviatile
B. minus
B. penna-marina
Cyathea smithii
Gleichenia cunninghamii
Grammitis billardieri
G. heterophylla
Histiopteris incisa
Hymenophyllum multifidum
H. sanguinolentum
Lycopodium sp.
Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum
Pteridium aquilinum var. *esculentum* (bracken)
Todea superba (Prince of Wales feather)

Al: r 52, r53, pt r54, r57, pt r105

A2. Kahikatea and matai co-dominant, plus cedar, other podocarps, and hardwoods

(i) Trees and Tall Shrubs

Aristotelia serrata (makomako, wineberry)
Carpodetus serratus
Cordyline australis (cabbage tree)
Dacrydium biforme
D. cupressinum (rimu, red pine)
Fuchsia excorticata (kotukutuku, fuchsia)
Griselinia littoralis
Leptospermum ericoides
Libocedrus bidwillii
Nothofagus fusca (red beech)
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
P. spicatus
Schefflera digitata (pate)
Weinmannia racemosa

(ii) Shrubs

Aristotelia fructicosa
Coprosma foetidissima

C. rhamnoides
C. rotundifolia
C. tenuicaulis
Elaeocarpus hookerianus
Gaultheria antipoda
Hebe salicifolia
Leptospermum scoparium
**Leycesteria formosa* (Himalayan honeysuckle)
Melicope simplex
Myrsine divaricata
Neomyrtus pedunculata
Pennantia corymbosa (kaikomako)
Pittosporum colensoi
P. eugenioides (tarata, lemonwood)
Pseudopanax anomalum

Pseudopanax crassifolium

Pseudowintera colorata

(iii) Lianes and Scramblers

Muehlenbeckia sp.

Parsonsia sp.

Rubus australis

R. cissoides

R. schmidelioides

(iv) Ground Cover and Epiphytes

Acaena sp.

Astelia sp.

Cardamine debilis

Cotula sp.

**Digitalis purpurea* (foxglove)

Earina autumnalis

E. mucronata

Gahnia sp.

Juncus spp.

**Lotus pedunculatus*

Luzuriaga parviflora

Microlaena avenacea

Nertera depressa

N. dichondraefolia

Phormium tenax (N.Z. flax)

**Plantago lanceolata*

**Prunella vulgaris*

**Ranunculus repens*

**Senecio jacobaea*

Uncinia spp.

Urtica sp.

(v) Ferns and Fern Allies

Asplenium bulbiferum (hen and chicken fern)

A. flaccidum

A. hookerianum

A. terrestre

Blechnum capense

B. fluviatile

B. lanceolatum

Blechnum minus
B. nigrum
B. penna-marina
B. vulcanicum
Cyathea smithii
Dicksonia squarrosa
Gleichenia cunninghamii
Grammitis billardieri
G. heterophylla
Histiopteris incisa
Hymenophyllus demissum
Hymenophyllum flabellatum
H. multifidum
H. pulcherrimmum
H. sanguinolentum
Leptolepia novae-zelandiae
Lycopodium sp.
Paesia scaberula
Phymatodes diversifolium
P. scandens
Polystichum vestitum
Pteridium aquilinum var. esculentum
Pyrrosia serpens
Thelypteris pennigera
Todea hymenophylloides
T. superba

A2v: pt b28

A2: pt b28, pt b30, pt w37, pt r43, r44, pt r58, r106

A3. Kahikatea dominant, plus other podocarps, cedar and hardwoods

(i) Trees and Tall Shrubs

Aristotelia serrata
Carpodetus serratus
Dacrydium biforme
D. cupressinum
Fuchsia excorticata
Elaeocarpus dentatus (hinau)
Griselinia littoralis
Leptospermum ericoides
Libocedrus bidwillii
Melicytus lanceolatus
Nothofagus fusca
Phyllocladus alpinus
Podocarpus acutifolius
P. dacryioides
P. ferrugineus
P. spicatus
Schefflera digitata
Weinmannia racemosa

(ii) Shrubs

Coprosma foetidissima
C. rhamnoides
C. rotundifolia
Elaeocarpus hookerianus
Leptospermum scoparium
Myrsine divaricata
Neomyrtus pedunculata
Pennantia corymbosa
Pittosporum colensoi
Pseudopanax anomalum
P. crassifolium
Pseudowintera colorata

(iii) Lianes and Scramblers

Metrosideros diffusa
Parsonsia sp.
Rubus australis
R. cissoides
**R. fructicosus*
R. schmidelioides

(iv) Ground Cover and Epiphytes

Acaena sp.
Astelia sp.
Gahnia sp.
Hydrocotyle sp.
Luzuriaga parviflora
Microlaena avenacea
Nertera depressa
N. dichondraefolia

Phormium tenax
**Prunella vulgaris*
Uncinia spp.

(v) Ferns and Fern Allies

Asplenium bulbiferum
A. flaccidum
A. polyodon
A. terrestre
Blechnum discolor
B. fluviatile
B. minus
B. penna-marina
Cyathea smithii
Dicksonia fibrosa (Arnold River only)
Dicksonia squarrosa
Gleichenia cunninghamii
Grammitis billardieri
G. heterophylla
Histiopteris incisa
Hymenophyllum demissum
H. flabellatum
H. multifidum
H. revolutum
H. sanguinolentum
Hypolepis sp.
Lycopodium billardieri
L. volubile
Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum
Todea superba

A3: b2, pt b10, pt b28, pt b31, pt r2

A4. Rimu and kahikatea co-dominant, plus other podocarps, cedar, and hardwoods

(i) Trees and Tall Shrubs

Aristotelia serrata
Carpodetus serratus
Dacrydium cupressinum
Fuchsia excorticata
Griselinia littoralis
Leptospermum ericoides
Libocedrus bidwillii
Nothofagus fusca
N. solandri var. cliffortioides (mountain beech)
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
P. spicatus
Weinmannia racemosa

(ii) Shrubs

Coprosma foetidissima
C. lucida
C. rotundifolia
C. tenuicaulis
Elaeocarpus hookerianus
Gaultheria antipoda
Hebe salicifolia
Leptospermum scoparium
Myrsine divaricata
Neomurtus pedunculata
Pseudopanax anomalum
P. crassifolium
Pseudowintera colorata
**Ulex europaeus* (gorse)

(iii) Lianes and Scramblers

Metrosideros diffusa
Muehlenbeckia sp.
Rubus australis
**R. fructicosus*
R. schmidelioides

(iv) Ground Cover and Epiphytes

Acaena sp.

Astelia sp.

Cardamine debilis

**Cirsium vulgare* (Scotch thistle)

**Digitalis purpurea*

Juncus sp.

Libertia pulchella

**Lotus pedunculatus*

Luzuriaga parviflora

Microlaena avenacea

Nertera depressa

N. dichondraefolia

**Prunella vulgaris*

**Ranunculus repens*

**Senecio jacobaea*

Uncinia sp.

(v) Ferns and Fern Allies

Asplenium flaccidum

A. terrestre

Blechnum capense

B. discolor

B. fluviatile

B. lanceolatum

B. minus

B. nigrum

B. patersonii

B. vulcanicum

Cyathea smithii

Dicksonia squarrosa

Gleichenia circinata

G. cunninghamii

Grammitis billardieri

G. heterophylla

Histiopteris incisa

Hymenophyllum demissum

H. multifidum

H. rarum

Hypolepis sp.

Leptolepia novae-zelandiae

Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum
Thelypteris pennigera
Todea superba

A4: pt bl, b7, b8, wl, pt wl9, pt rl05

A5. Red beech dominant, plus podocarps, cedar, and hardwoods

(i) Trees and Tall Shrubs

Aristotelia serrata
Carpodetus serratus
Dacrydium cupressinum
D. colensoi
Elaeocarpus dentatus
Fuchsia excorticata
Griselinia littoralis
Libocedrus bidwillii
Melicytus ramiflorus (mahoe)
Myrsine salicina (toro)
Nothofagus fusca
N. solandri var.*cliffortioides*
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
P. spicatus
Quintinia acutifolia
Schleffera digitata (pate)
Weinmannia racemosa

(ii) Shrubs

Archeria traversii
Carmichaelia grandiflora-angustata complex
Coprosma foetidissima
C. lucida
C. rhamnoides
C. rotundifolia
Cyathodes fasciculata
Gaultheria antipoda
Hebe salicifolia
Hoheria glabrata
Leptospermum scoparium
Melicope simplex
Myrsine divaricata
Neomyrtus pedunculata
Olearia avicenniaefolia
O. ilicifolia
Pennantia corymbosa
Phormium tenax

Pseudopanax anomalum
P. crassifolium
P. edgerleyi
P. simplex
Pseudowintera colorata
**Ulex europaeus*

(iii) Lianes and Scramblers

Clematis sp.
Metrosideros diffusa
Meuhlenbeckia sp.
Parsonsia sp.
Ripogonum scandens (supplejack)
Rubus australis
R. cissoides
R. schmidelioides
R. squarrosus

(iv) Ground Cover and Epiphtes

Acaena sp.
Astelia sp.
Cardamine debililis
Carex sp.
**Cirsium arvense* (Californian thistle)
**C. vulgare*
Cortaderia richardii
Dendrobium cunninghamii
Dianella nigra
**Digitalis purpurea*
Earina autumnalis
Grahnia sp.
Gunnera sp.
Haloragis sp.
Juncus sp.
**Lotus pedunculatus*
Luzuriaga parviflora
Microlaena avenacea
Nertera depressa
N. dichondraefolia
Pratia angulata
**Prunella vulgaris*
**Ranunculus repens*
**Senecio jacobaea*

Uncinia spp.

(v) Ferns and Fern Allies

Asplenium bulbiferum
A. flaccidum
A. polyodon
A. terrestre
Blechnum capense
B. discolor
B. fluviatile
B. lanceolatum
B. minus
B. penna-marina
B. vulcanicum
Cyathea smithii
Dicksonia squarrosa
Gleichenia circinata
G. cunninghamii
Grammitis billardieri
G. heterophylla
Histiopteris incisa
Hymenophyllum demissum
H. flabellatum
H. multifidum
H. sanguinolentum
Hypolepis sp.
Lycopodium volubile
Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum
Pteridium aquilinum var. esculentum
Thelypteris pennigera
Todea superba

A5: pt b8, pt b22, pt b30, pts b31, b32, pt b33, pt w4, w12, pt w16, w17, pt w18, pt w19, pt w34, pt w37, pt r1, pt r2, pt r5, pt r54, pt r58.

Blv & Bl. Kahikatea and rimu, plus other podocarps, cedar, and hardwoods

(i) Trees and Tall Shrubs

Aristotelia serrata
Carpodetus serratus
Dacrydium biforme
D. colensoi
D. cupressinum
Elaeocarpus dentatus
Griselinia littoralis
Libocedrus bidwillii
Melicytus ramiflorus
Myrsine australis (mapau)
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
P. spicatus
Quintinia acutifolia
Weinmannia racemosa

(ii) Shrubs

Archeria traversii
Coprosma foetidissima
C. rhamnoides
C. rotundifolia
C. tenuicaulis
Cyathodes fasciculata
Elaeocarpus hookerianus
Gaultheria antipoda
Hebe salicifolia
Leptospermum scoparium
Myrsine divaricata
Neomyrtus pedunculata
Pennantia corymbosa
Pseudopanax anomalum
P. crassifolium
P. simplex
Pseudowintera colorata

(iii) Lianes and Scramblers

Clematis sp.
Metrosideros diffusa
Muehlenbeckia sp.
Parsonsia sp.
Rubus australis
R. cissoides
**R. fructicosus*
R. schmidelioides

(iv) Ground Cover and Epiphytes

Acaena sp.
Cardamine debilis
Gahnia sp.
Gnaphalium sp.
Hydrocotyle dissecta
Juncus sp.
Libertia pulchella
**Lotus pedunculatus*
Microlaena avenacea
Nertera depressa
N. dichondraefolia
Phormium tenax
Pterostylis sp.
**Ranunculus repens*
Uncinia sp.
Urtica sp.

(v) Ferns and Fern Allies

Asplenium bulbiferum
A. flaccidum
A. terrestre
Blechnum capense
B. discolor
B. fluviatile
B. minus
B. vulcanicum
Cyathea smithii
Dicksonia squarrosa
Gleichenia circinata
C. cunninghamii
Grammitis billardieri

G. heterophylla
Histiopteris incisa
Hymenophyllum demissum
H. flabellatum
H. multifidum
H. revolutum
H. sanguinolentum
Lycopodium sp.
Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum
Pteridium aquilinum var. *esculentum*
Pyrrosia serpens
Rumohra hispida
Todea superba

Blv: pt w32, pt r15

Bl: pt b1, b4, b5, b6, b9, b11, b12, pt b30, pt w2, pt w5, pt w9, w10, pt w15, pt w19, pt w20, w21, w23, pt w26, pt w27, pt w32, pt w33, w59, pt r15, r16, pt r18, pt r24, r34, pt r43, pt r59, pt r76, pt r81, r82, r83, r84, pt r85, r87, r89, r90, pt r103, r107, r108.

B2v & B2. Rimu, plus other podocarps, cedar, and hardwoods

(i) Trees and Tall Shrubs

Aristotelia serrata
Carpodetus serratus
Dacrydium biforme
D. colensoi
D. cupressinum
Elaeocarpus dentatus
Griselinia littoralis
Libocedrus bidwillii
Melicytus ramiflorus
Myrsine australis
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
Quintinia acutifolia
Weinmannia racemosa

(ii) Shrubs

Archeria traversii
Coprosma foetidissima
C. lucida
C. rotundifolia
C. tenuicaulis
Cyathodes fasciculata
Elaeocarpus hookerianus
Gaultheria sp.
Hebe salicifolia
Leptospermum scoparium
Myrsine divaricata
Neomyrtus pedunculata
Pseudopanax anomalum
P. crassifolium
Pseudowintera colorata

(iii) Lianes and Scramblers

Clematis sp
Metrosideros diffusa
M. fulgens
Muehlenbeckia sp.
Ripogonum scandens

Rubus australis

R. cissoides

(iv) Ground Cover and Epiphytes

**Cirsium arvense*

Dendrobium cunninghamii

**Digitalis purpurea*

Earina autumnalis

Gahnia sp.

Juncus sp.

Libertia pulchella

**Lotus pedunculatus*

Luzuriaga parviflora

Microlaena avenacea

Nertera depressa

N. dichondraefolia

**Ranunculus repens*

Uncinia spp.

(v) Ferns and Fern Allies

Asplenium bulbiferum

A. flaccidum

A. terrestre

Blechnum capense

B. discolor

B. fluviatile

B. minus

Cyathea smithii

Dicksonia squarrosa

Gleichenia circinata

G. cunninghamii

Grammitis billardieri

G. heterophylla

Histiopteris incisa

Hymenophyllum demissum

H. flabellatum

H. lyallii

H. multifidum

H. sanguinolentum

Hypolepis sp.

Paesia scaberula

Phymatodes diversifolium

Polystichum vestitum
Pyrrosia serpens
Rumohra hispida
Thelypteris pennigera
Todea superba

B2v: w29, pt w32, pt w38, w41, pt r2, pt r7, pt r15, pt r24

B2: pt b13, pt b29, pts b30, w11, pt w32, pt w33, pt w38, pt w41, w56, pt r2, r3, pt r4, r6, pt r8, r19, r22, r23, pt r24, r35, pts r105,

B3. Kahikatea and rimu emergent above cedar, toatoa, pink pine, manuka and kamahi canopy

(i) Trees and Tall Shrubs

Carpodetus serratus
Dacrydium biforme
D. colensoi
D. cupressinum
Griselinia littoralis
Libocedrus bidwillii
Myrsine australis
Phyllocladus alpinus
Pittosporum colensoi
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
Quintinia acutifolia
Weinmannia racemosa

(ii) Shrubs

Coprosma foetidissima
C. rotundifolia
Cyathodes fasciculata
Elaeocarpus hookerianus
Gaultheria antipoda
Hoheria glabrata
Leptospermum scoparium
Myrsine divaricata
Neomyrtus pedunculata
Pseudopanax anomalum
P. crassifolium
Pseudowintera colorata

(iii) Lianes and Scramblers

Clematis sp.
Ripogonum scandens
Rubus australis
R. cissoides
R. squarrosus

(iv) Ground Cover and Epiphytes

Acaena sp.
**Cirsium vulgare*
**Digitalis purpurea*
Gahnia sp.

Hydrocotyle dissecta
Luzuriaga parviflora
Microlaena avenacea
Nertera depressa
N. dichondraefolia
**Plantago lanceolata*
Uncinia sp.
Urtica sp.

(v) Ferns and Fern Allies

Asplenium bulbiferum
A. flaccidum
A. terresire
Blechnum capense
B. discolor
B. fluviatile
B. minus
B. penna-marina
Cyathea smithii
Dicksonia squarrosa
Gleichenia cunninghamii
Grammitis billardieri
G. heterophylla
Hymenophyllum demissum
H. flabellatum
H. multifidum
H. sanguinolentum
Hypolepis sp.
Lycopodium volubile
Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum
Rumohra adiantiformis
Todea superba

B3: pt b20, pt w30, w31, w35, pt r4, pt r5, pt r15, pt r24, pt r25.

B4. Cedar, pink pine, toatoa, and manuka

(i) Trees and Tall Shrubs

Dacrydium biforme
D. colensoi
D. cupressinum
Griselinia littoralis
Leptospermum scoparium
Libocedrus bidwillii
Nothofagus fusca
N. solandri var. cliffordioides
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. hallii

(ii) Shrubs

Archeria traversii
Coprosma spp.
Elaeocarpus hookerianus
Myrsine divaricata
Neomyrtus pedunculata
Pseudopanax anomalum
P. crassifolium
Pseudowintera colorata

(iii) Lianes and Scramblers

Muehlenbeckia sp.
Rubus australis

(iv) Ground Cover and Epiphytes

Acaena sp.
Cardamine debilis
**Digitalis purpurea*
Hydrocotyle dissecta
Luzuriaga parviflora
**Senecio jacobaea*

(v) Ferns and Fern Allies

Asplenium flaccidum
A. terrestre
Blechnum fluviatile
B. minus
B. penna-marina
Dicksonia squarrosa

Gleichenia circinata
G. cunninghamii
Grammitis billardieri
Histiopteris incisa
Hymenophyllum demissum
H. multifidum
H. sanguinolentum
Hypolepis sp.
Phymatodes diversifolium
Polystichum vestitum

B4: pts b30, pt w19, pt w34, w36, w57, pt r2, pt r4, pt r8, pt r13, r21.

B5. Mountain beech dominant, plus podocarps and other hardwoods

(i) Trees and Tall Shrubs

Dacrydium biforme
D. colensoi
D. cupressinum
Libocedrus bidwillii
Nothofagus fusca
N. solandri var.*cliffortioides*
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
Quintinia acutifolia
Weinmannia racemosa

(ii) Shrubs

Archeria traversii
Coprosma foetidissima
Cyathodes fasciculata
Elaeocarpus hookerianus
Leptospermum scoparium
Myrsine divaricata
Neomyrtus pedunculata
Pseudopanax anomalum
P. crassifolium
P. simplex
Pseudowintera colorata

(iii) Lianes and Scramblers

Rubus australis

(iv) Ground Cover and Epiphytes

Cardamine debilis
Dendrobium cunninghamii
Earina autumnalis
Luzuriaga parviflora
Microlaena avenacea
Uncinia sp.

(v) Ferns and Fern Allies

Asplenium flaccidum
Asplenium terrestre
Blechnum discolor
B. minus

Dicksonia squarrosa
Gleichenia circinata
G. cunninghamii
Grammitis billardieri
G. heterophylla
Hymenophyllum demissum
H. flabellatum
H. malingii
H. multifidum
H. sanguinolentum
Paesia scaberula
Phymatodes diversifolium

B5: pt b20, pt b30, pt b33, b34, pt w34, pt r1, pt r2, pt r5, pt r7, pt r58

B6. Red beech dominant, plus mountain beech, podocarps, and other hardwoods

(i) Trees and Tall Shrubs

Dacrydium colensoi
D. cupressinum
Elaeocarpus dentatus
Griselinia littoralis
Libocedrus bidwillii
Nothofagus fusca
N. solandri var. *cliffortioides*
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
Quintinia acutifolia
Weinmannia racemosa

(ii) Shrubs

Archeria traversii
Coprosma foetidissima
C. lucida
C. tenuicaulis
Cyathodes fasciculata
Elaeocarpus hookerianus
Leptospermum scoparium
Myrsube australis
M. divaricata
Neomyrtus pedunculata
Pseudopanax anomalum
P. crassifolium
P. simplex
Pseudowintera colorata
**Ulex europaeus*

(iii) Lianes and Scramblers

Rubus australis

(iv) Ground Cover and Epiphytes

Dendrobium cunninghamii
Earina autumnalis
Luzuriaga parviflora
Microlaena avenacea
Nertera depressa
N. dichondraefolia
Uncinia sp.

(v) Ferns and Fern Allies

Asplenium flaccidum
A. terrestre
Blechnum discolor
B. minus
B. penna-marina
B. vulcanicum
Cyathea smithii
Dicksonia squarrosa
Gleichenia cunninghamii
Grammitis billardieri
G. heterophylla
Histiopteris incisa
Hymenophyllum demissum
H. flabellatum
H. multifidum
H. rarum
H. sanguinolentum
H. scabrum
Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum
Pteridium aquilinium var. *esculentum*

B6: b19, pts b20, pt b30, pt w18, pt w19, w58, r97, pt r102, pt 103

B7. Silver beech

(i) Trees and Tall Shrubs

Griselinia littoralis

Nothofagus fusca

N. menziesii (silver beech)

N. solandri var. *cliffortioides*

Phyllocladus alpinus

Podocarpus acutifolius

P. hallii

Quintinia acutifolia

(ii) Shrubs

Coprosma foetidissima

Elaeocarpus hookerianus

Leptospermum scoparium

Myrsine divaricata

Neomyrtus pedunculata

Pseudopanax anomalum

P. crassifolium

(iii) Lianes and Scramblers

Rubus asutralis

(iv) Ground Cover (* = seedlings only)

*Dacrydium colensoi**

*D. cupressinum**

*Elaeocarpus dentatus**

Microlaena avenacea

Nertera depressa

*Podocarpus dacrydioides**

*P. ferrugineus**

Uncinia spp.

(v) Ferns and Fern Allies

Asplenium flaccidum

A. terrestre

Blechnum discolor

B. fluviatile

B. minus

Cyathea smithii

Dicksonia squarrosa

Gleichenia cunninghamii
Grammitis billardieri
G. heterophylla
Hymenophyllum demissum
H. flabellatum
H. multifidum
H. sanguinolentum
Paesia scaberula

B7: pt wl9

Clv & Cl. Rimu and miro emergent above canopy of kamahi, quintinia, toatoa broadleaf and marbleleaf

(i) Trees and Tall Shrubs

Aristotelia serrata
Carpodetus serratus
Dacrydium colensoi
D. cupressinum
Elaeocarpus dentatus
E. hookerianus
Fuchsia excorticata
Griselinia littoralis
Hedycarya arborea (pigeonwood)
Leptospermum ericoides
Libodedrus bidwillii
Melicytus lanceolatus
M. ramiflorus
Metrosideros umbellata (southern rata)
Myrsine australis
M. salicina
Phyllocladus alpinus
Pittosporum eugenioides
Podocarpus acutifolius
P. dacrydioides
P. ferrugineus
P. hallii
Quintinia acutifolia
Schefflera digitata
Weinmannia racemosa

(ii) Shrubs

Archeria traversii
Coprosma australis
C. foetidissima
C. lucida
C. rhamnoides
C. rotundifolia
C. tenuicaulis
Cyathodes fasciculata
Gaultheria antipoda
Hebe salicifolia
Hoheria glabrata

Leptospermum scoparium
**Leycesteria formosa*
Myrsine divaricata
Neomyrtus pedunculata
Pennantia corymbosa
Pittosporum colensoi
Pseudopanax anomalum
P. colensoi
P. crassifolium
P. simplex
Pseudowintera colorata
**Ulex europaeus*

(iii) Lianes and Scramblers

Clematis sp.
Metrosideros diffusa
M. fulgens
M. perforata
Muehlenbeckia sp.
Parsonsia sp.
Ripogonum scandens
Rubus australis
R. cissoides
**R. fructicosus*

(iv) Ground Cover and Epiphytes

Acaena sp.
Astelia sp.
Cardamine debilis
Carex sp.
Centella uniflora
**Cirsium vulgare*
**Crepis capillaris*
Dendrobium cunninghamii
**Digitalis purpurea*
Earina autumnalis
E. mucronata
Gahnia sp.
**Hypochoeris radicata*
Juncus sp.
**Leycesteria formosa*
Libertia pulchella

Lotus pedunculatus
Luzuriaga parviflora
Microlaena avenacea
Nertera depressa
N. dichondraefolia
**Ranunculus repens*
**Senecio jacobaea*
Uncinia spp.

(v) Ferns and Fern Allies

Adiantum sp.
Asplenium bulbiferum
A. flaccidum
A. polyodon
A. terrestre
Blechnum capense
B. discolor
B. fluviatile
B. lanceolatum
B. minus
B. nigrum
B. patersonii
B. vulcanicum
Cyathea colensoi
C. smithii
Dicksonia squarrosa
Gleichenia circinata
G. cunninghamii
Grammitis billardieri
G. heterophylla
Histiopteris incisa
Hymenophyllum demissum
H. flabellatum
H. lyalli
H. multifidum
H. sanguinolentum
Hypolepis sp.
Lindsaea trichomanoides
Lycopodium volubile
Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum

Pteridium aquilinum var. *esculentum*
Pyrrosia serpens
Rumohra adiantiformis
Tmesipteris tannensis
Todea superba
Trichomanes reniforme

Clv: pt w4, pt r76

Cl: pt b10, pt b13, b14, b15, pt b16, b21, b23, b24, b25, b26, b27, pt b28, pt b29,pt b30, pt w2, w3, pt w4, pt w5, w6, w7, w8, pt w9, pt w13, w14, pt w20, w39, w40, pt w41, w42, w43, w44, w46, w47, w48, w49, w50, w51, w52, w53, w54, w55, w60, w61, w62, pt r2, r11, r12, pt r13, r14, pt r24, pt r25, r26, r27, r29, r33, r36, r37, r38, pt r40, r46, r47, r48, r50, pt r59, r60, r61, r62, r63, r64, r65, r66, r70, r71, r72, r73, r74, r75, pt r76, r77, pt r78, r79, r80, pt r85, r86, pt r88, r91, r92, r93, r94, r95, pt r103, r104, pt r105

C2. Secondary kahikatea dominant, plus hardwoods and other podocarps

(i) Trees and Tall Shrubs

Dacrydium colensoi
D. cupressinum
Griselinia littoralis
Phyllocladus alpinus
P. hallii
Weinmannia racemosa

(ii) Shrubs

Coprosma foetidissima
C. rotundifolia
C. tenuicalus
Elaeocarpus hookerianus
Leptospermum scoparium
Myrsine divaricata
Neomyrtus pedunculata
Pseudopanax crassifolium
Pseudowintera colorata

(iii) Lianes and Scramblers

Metrosideros fulgens
Parsonsia sp.
Rubus australis
R. cissoides
**R. fructicosus*
R. schmidelioides

(iv) Ground Cover and Epiphytes

Acaena sp.
**Digitalis purpurea*
Microlaena avenacea
**Prunella vulgaris*
**Ranunculus repens*
Uncinia sp.

(v) Ferns and Fern Allies

Blechnum discolor
B. fluviatile
B. minus
Dicksonia squarrosa
Grammitis billardieri
Histiopteris incisa
Paesia scaberula

Phymatodes diversifolium
Polystichum vestitum

C2: r32, r67, r68, r69, pt r76, pt r78, pt r88

D1v & D1. Rimu and miro emergent above canopy of kamahi, quintinia, pokaka, southern rata and other hardwoods

(1) Trees and Tall Shrubs

Aristotelia serrata
Carpodetus serratus
Dacrydium cupressinum
Elaeocarpus dentatus
E. hookerianus
Fuchsia exorticata
Griselinia littoralis
Leptospermum ericoides
Melicytus ramiflorus
Metrosideros umbellata
Myrsine australis
M. salicina
Phyllocladus alpinus
Pittosporum eugenioides
Podocarpus dacrydioides
P. ferrugineus
P. hallii
Quintinia acutifolia
Schefflera digitata
Weinmannia racemosa

(ii) Shrubs

Coprosma australis
C. foetidissima
C. lucida
C. rotundifolia
Myrsine divaricata
Neomyrtus pedenculata
Pennantia corymbosa
Pseudopanax colensoi
P. crassifolium
Pseudowintera colorata

(iii) Lianes and Scramblers

Clematis sp.
Metrosideros diffusa
M. fulgens
Ripogonum scandens
Rubus australis
R. cissoides

(iv) Ground Cover and Epiphytes

Acaena sp.

Astelia sp.

Carex sp.

**Cirsium vulgare*

Dendrobium cunninghamii

Earina autumnalis

Gahnia sp.

Gunnera sp.

Juncus sp.

Libertia pulchella

**Lotus pedunculatus*

Microlaena avenacea

Nertera depressa

N. dichondraefolia

**Ranunculus repens*

Uncinia sp.

(v) Ferns and Fern Allies

Asplenium bulbiferum

A. flaccidum

A. polyodon

A. terrestre

Blechnum capense

B. discolor

B. flaviatile

B. lanceolatum

B. minus

B. nigrum

B. patersonii

Cyathea smithii

Dicksonia squarrosa

Gleichenia circinata

G. cunninghamii

Grammitis billardieri

G. heterophylla

Histiopteris incisa

Hymenophyllum bivalve

H. demissum

H. dilatum

H. flabellatum

H. lyalli

H. multifidum

Hymenophyllum pulcherrimum
H. revolutum
H. sanguinolentum
Leptolepia novae-zelandiae
Lindsaea trichomanoides
Phymatodes diversifolium
Polystichum vestitum
Rumohra adiantiformis
R. hispida
Thelypteris pennigera
Tmesipteros tannensis
Todea superba
Trichomanes reniforme

Dlv: pt b3, pt bl6, pt bl7
Dl: pt b3, pt bl6, pt bl7, bl8, pt b22

E1. Shrublands with significant hardwood and/or podocarp regeneration

(1) Shrubs, Scramblers and Young Tree Species

Archeria traversii
Aristotelia serrata
Coprosma foetidissima
C. rhamnoides
C. tenuicaulis
Dacrydium biforme
D. colensoi
D. supressinum
Elaeocarpus hookerianus
Gaultheria antipoda
Griselinia littoralis
Hebe salicifolia
Leptospermum ericoides
L. scoparium
Libocedrus bidwillii
Muehlenbeckia sp.
Myrsine divaricata
Neomyrtus pedunculata
Phyllocladus alpinus
Pittosporum colensoi
Podocarpus acutifolius
P. dacrydioides
P. spicatus
Pseudopanax anomalum
P. crassifolium
Pseudwintera colorata
Quintinia acutifolia
Rubus australis
R. cissoides
**R. fructicosus*
R. schmidelioides
**Ulex europaeus*
Weinmannia racemosa

(ii) Ground Cover

Acena sp.
Centella uniflora
**Digitalis purpurea*
Gahnia sp.
**Hypochoeris radicata*

Juncus sp.
Microlaena avenacea
**Prunella vulgaris*
**Ranunculus repens*
Uncinia spp.

(iii) Ferns and Fern Allies

Asplenium flaccidum
Blechnum discolor
B. fluviatile
B. minus
B. vulcanicum
Cyathea smithii
Dicksonia squarrosa
Gleichenia cunninghamii
Histiopteris incisa
Lycopodium ap.
Paesia scaberula
Phymatodes diversifolium
Polystichum vestitum
Pteridium aquilinum var. *esculentum*
Pyrrosia serpens

El: pt b30, pt w4, pt w15, pt w16, pt w33, pt r5, pt r7, r10, r30, r39, pt r40, r41, r42, r45, r51, pt r54, r56, pt r58, r96.

E2. Shrublands without significant hardwood or podocarp regeneration

(i) Shrubs, Scramblers and Young Tree Species

Aristotelia serrata
Coprosma foetidissima
C. tenuicaulis
Dacrydium biforme
D. colensoi
D. cupressinum
Griselinia littoralis
Leptospermum ericoides
L. scoparium
Libocedrus bidwillii
Myrsine divaricata
Neomyrtus pedunculata
Nothofagus solandri var. *cliffortioides*
Phyllocladus alpinus
Podocarpus acutifolius
P. dacrydioides
P. hallii
Pseudopanax crassifolium
Rubus australis
R. cissoides
**R. fructicosus*
**Ulex europaeus*
Weinmannia racemosa

(ii) Ground Cover

Acaena sp.
Centella uniflora
**Digitalis purpurea*
Gahnia sp.
**Hypochoeris radicata*
Juncus sp.
**Ranunculus repens*
Uncinia spp.

(iii) Ferns and Fern Allies

Blechnum discolor
B. fluviatile
B. minus
Dicksonia squarrosa
Gleichenia circinata
G. cunninghamii

Histiopteris incisa
Lycopodium sp.
Paesia scaberula
Pteridium aquilinum var. *esculentum*

E2: pt b20, pt w13, pt w15, pt w18, pt w20, w22, w24, w25, pt w26, pt w27, w28, pt w30, pt w32, w45, pt r2, pt r4, r9, pt r15, r17, pt r18, r20, r28, r31, r55, pt r81, r98, r99, r100, r101, pt r102, pt r105

Appendix 3: Average Number of Native Bird Species in Forest Remnants on Ruru, Weka and Blairs blocks (Data used in Figure 8).

Area	Ruru	Weka	Blairs	Total
0-2 ha	$X = 123$	$X = 45$	$X = 15$	$X_T = 183$
	$n = 67$	$n = 31$	$n = 10$	$N = 108$
	$\bar{X} = 1.84$	$\bar{X} = 1.45$	$\bar{X} = 1.5$	$\bar{X}_T = 1.69$
2-4 ha	$X = 61$	$X = 21$	$X = 19$	$X_T = 101$
	$n = 14$	$n = 5$	$n = 5$	$N = 24$
	$\bar{X} = 4.36$	$\bar{X} = 4.2$	$\bar{X} = 3.8$	$\bar{X}_T = 4.21$
4-8 ha	$X = 40$	$X = 53$	$X = 16$	$X_T = 109$
	$n = 7$	$n = 12$	$n = 4$	$N = 23$
	$\bar{X} = 5.71$	$\bar{X} = 4.42$	$\bar{X} = 4.0$	$\bar{X}_T = 4.74$
8-12 ha	$X = 42$	$X = 7$	$X = 16$	$X_T = 65$
	$n = 6$	$n = 2$	$n = 3$	$N = 11$
	$\bar{X} = 7.0$	$\bar{X} = 3.5$	$\bar{X} = 5.33$	$\bar{X} = 5.91$
12-16 ha	$X = 35$	$X = 12$	-	$X_T = 47$
	$n = 6$	$n = 2$	-	$N = 8$
	$\bar{X} = 5.83$	$\bar{X} = 6.0$	-	$\bar{X}_T = 5.88$
16-20 ha	$X = 7$	$X = 13$	-	$X_T = 20$
	$n = 1$	$n = 2$	-	$N = 3$
	$\bar{X} = 7.0$	$\bar{X} = 6.5$	-	$\bar{X} = 6.67$
20-30 ha	$X = 6$	$X = 32$	$X = 23$	$X_T = 61$
	$n = 1$	$n = 4$	$n = 4$	$n = 9$
	$\bar{X} = 6.0$	$\bar{X} = 8.0$	$\bar{X} = 5.75$	$\bar{X}_T = 6.78$
30-40 ha	$X = 8$	$X = 7$	$X = 17$	$X_T = 32$
	$n = 1$	$n = 1$	$n = 2$	$N = 4$
	$\bar{X} = 8.0$	$\bar{X} = 7.0$	$\bar{X} = 8.5$	$\bar{X} = 8.00$
40-50 ha	$X = 20$	$X = 17$	$X = 10$	$X_T = 47$
	$n = 2$	$n = 2$	$n = 1$	$N = 5$
	$\bar{X} = 10.0$	$\bar{X} = 8.5$	$\bar{X} = 10.0$	$\bar{X}_T = 9.40$
50+ ha	$X = 18$	-	$X = 24$	$X_T = 42$
	$n = 2$	-	$n = 3$	$n = 5$
	$\bar{X} = 9.0$	-	$\bar{X} = 8.0$	$\bar{X}_T = 8.40$

NOTES:

1. $\bar{X}$ = Average frequency of bird species in forest remnants in the specified size class on Ruru, Weka and Blairs blocks.

   $\bar{X}_T$ = Average frequency of bird species in forest remnants in the specified size class on the Farm Settlement.

   n = Number of forest remnants (total N = 200)

2. No data were recorded for four remnants, all in the first three size classes.

APPENDIX 4: Brief Notes on Bird Species Recorded on Bell Hill Farm Settlement[1]

S.I. Fantail*: Very common in even smallest areas of forest and shrubland, especially near water; sometimes ventures into the open.

Grey Warbler*: Very common in even smallest areas of forest and shrubland.

Silvereye*: Common in even smallest areas of forest and shrubland; often seen in flocks.

Bellbird*: A relatively mobile species common in all but the smallest forest remnants.

Western Weka*: Common in shrublands and around forest edges, but uncommon within the forest.

Yellow-breasted Tit*: Common in forest and shrubland but often absent from isolated forest remnants.

Tui*: A mobile species generally found in larger forest remnants, particularly those adjacent to Mawhera forest. Rarely seen in mid-winter, 1980.

Brown Creeper*: After the breeding season, usually seen in flocks in some of the larger forest remnants.

N.Z. Pigeon*: A mobile species restricted to larger forest remnants, particularly those adjacent to Mawhera and Otira-Kopara forests and Bell Hill and Arnold River scenic reserves.

Kingfisher*: Recorded in low numbers around forest-enclosed parts of Jones and Piper Creeks.

S.I. Robin*: 3-4 birds recorded in beach-podocarp forest in the north-eastern corner of Ruru block, adjacent to Mawhera forest. Because robins are sedentary and highly territorial, any extension of their range is likely to be a very slow process.

S.I. Rifleman*: A few occur in beech-podocarp forest in the north-east corner of Ruru block and in podocarp-hardwood hill country forest on Blairs block.

Long-Tailed Cuckoo*: Recorded three times during present survey, in large forest remnants. A survey earlier in the season would probably indicate a greater abundance.

Morepork*: A nocturnal bird, recorded only twice but probably common.

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1. Native species denoted by asterisk (*).

Shining Cuckoo*: Only one recorded, but was either silent or absent during most of the survey period.

S.I. Fernbird*: See section 2.6.3.3 (b).

Great Spotted Kiwi*: Occurs in Otira-Kopara forest east of the Farm Settlement (Hellyer, 1979). It is possible that at least six kiwi-like probes on an upturned stump in forest remnant r65 north-west of Kangaroo Lake (map reference S52: 023705) can be attributed to this species.

Parakeet species*: Recorded in the Bell Hill region (Bull *et al.*, 1978), probably in Mawhera or Otira-Kopara forests. Parakeets are a wide-ranging species and may be expected to be occasional visitors to Farm Settlement forest remnants.

S.I. Kaka*: Possibly an occasional visitor, but requires large tracts of forest habitat.

N.Z. Falcon*: Though not personally seen despite extensive searching, the falcon has been reported in the area by two local people. (Drake (1977) records it at nearby Lady Lake.

Kea*: Occurs in the mountainous country of Otira-Kopara forest, and is occassionally seen flying across the Farm Settlement towards Lake Brunner or Mt Te Kinga.

N.Z. Pipit*: Occurs in rough open country and is fairly common on the Farm Settlement. However it is usually not found on pasture land, and its numbers will probably decline as development proceeds.

Spur-winged Plover*: Present in moderate numbers on pasture lands, sometimes in small flocks. In larger flocks in mid-winter 1980, and probably more numerous.

Pukeko*: Common on the Farm Settlement, especially in swampy areas or around ponds. It is locally regarded as a nuisance for its habit of raiding haybarns.

Welcome Swallow*: A mobile species, sometimes seen in flocks on farm ponds.

Little Shag*: Seen occasionally on farm ponds and along Deep Creek.

Black Shag*: Only one seen, on a large farm pond.

Grey Duck*: Seen on farm ponds and on Deep Creek, sometimes in large flocks.

Mallard: Occasionally seen on farm ponds.

Paradise Shelduck*: Occurs on ponds and open pasture, sometimes in flocks.

Australasian Harrier*: A predator and scavenger commonly seen in open habitats.

Southern Black-backed Gull*: An occasionally seen scavenger on the Farm Settlement.

White-faced Heron*: Occasionally seen on farm ponds and open pastures.

Australian Little Grebe*: See section 2.6.3.3 (b).

White-backed Magpie: A flock commonly seen on Ruru block in 1979, but absent in mid-winter 1980.

Black-backed Magpie: Rarely seen, among white-backed magpies.

Hedge Sparrow: Occasionally seen but often heard in forest and shrubland habitats.

The following 10 introduced species are commonly found in open habitats, and some also extend into forest and shrublands:
Skylark, Blackbird, Song Thrush, Chaffinch, Greenfinch, Goldfinch, Redpoll, Starling, House Sparrow and Yellowhammer.

Appendix 5: Derivation of General Formula for Conservation Status Index (C.S.I.)

In forest remnants where there is more than one plant community-area-modification combination, some objective method is needed to incorporate all combinations in the overall forest remnant score. The method used here is based on the observation that the value of the forest remnant obviously cannot be less than the highest single score, and that additional scores add to the forest remnant value, but in a rapidly decreasing fashion.

The method is:

1. Sum each combination separately, on Crieteria I, II and III, and list them in order of decreasing value (y_1, y_2, y_3, ...). The maximum score is 180.

2. Take the highest score (y_1). For the next highest score (y_2), add to y_1 a value which is directly proportional to y_2 and to one-quarter of the remaining possible value on the three criteria i.e. $\frac{(180 - y_1)\, y_2}{4 \times 180}$ (hereafter referred to as $X_2/4$).

3. For the third highest score (y_3), add to the value already obtained ($X_2/4$) a value which is directly proportional to y_3 and to one-ninth of the remaining possible value i.e. $\frac{(180 - X_2)\, y_3}{9 \times 180}$ (hereafter referred to as $X_3/9$).

4. The proceedure is repeatable for the next and following combinations if need be.

5. The derived score of the forest remnant on the first three cirteria then becomes an arithmetic series of the form:

$$X_T = X_1 \ (= y_1) + X_2/4 + X_3/9 + \ldots + X_n/n^2 \qquad (5)$$

The series may be expressed by the following general formula:

$$X_T = \sum_{i=1}^{n} X_i/n^2 \qquad (6)$$

where $\sum_{i=1}^{n}$ signifies "sum over n terms"

n = number of plant community - area - modification combinations per forest remnant

X_T = derived sum score of all combinations on Criteria I, II and III

$X_i = (180 - X_{i-1}) \frac{y_i}{180}$ $\quad (X_0 = 0)$

y_i = sum score of each combination on Criteria I, II and III

$(y_1 \geqslant y_2 \geqslant y_3 \geqslant \ldots \geqslant y_n)$

For the cases of n = 1, n = 2, and n = 3, the formula reduces to formulae (1), (2) and (3) in the text (section 3.4.3). The C.S.I. is found by substituting the value of X_T from formula (5) into formula (4) (section 3.4.3).

For multiple combination forest remnants, C.S.I. values obtained using formulae (5) and (6) agree closely with considered estimates.

Examples:

1. Consider a hypothetical forest remnant of two communities. The remnant is ranked D on Criterion IV, and its two communities are ranked ADA and AAD on Criteria I, II and III (Table 6).
   Referring to Table 7, the forest remnant scores numerical values of 15 on Criterion IV ($=x_{IV}$), and the two communities 150 ($=y_1$) and 144 ($=y_2$) respectively on Criteria I, II and III.

   The derived score (X_T) of the two communities on Criteria I, II and III is found by substituting y_1 and y_2 in formula (2) (section 3.4.3):

   $$X_T = 150 + (180 - 150)\ \frac{144}{720}$$

   $$= 150 + 6$$

   The C.S.I. for the forest remnant is found by substituting for X_T and x_{IV} in formula (4) (section 3.4.3):

   $$\text{C.S.I.} = \frac{156 + 15}{240} \times \frac{100}{1}$$

   $$= 71\%$$

2. Consider further the same forest remnant but with an added community ranked CAD and (from Table 7) scoring 108 ($=y_3$)
   The derived score of the three communities is found by substituting y_1, y_2, and y_3 in formula (3) (section 3.4.3):

   $$X_T = 150 + 6 + (180 - [150 + 6])\ \frac{108}{1620} = 157.6$$

   The C.S.I. is found by substituting for X_T and x_{IV} in formula (4) (section 3.4.3):

   $$\text{C.S.I.} = \frac{(157.6 + 15)}{240} \times \frac{100}{1}$$

   $$= 72\%$$

Appendix 6: Conservation Status Index Values of Forest Remnants

C.S.I. Value (%)	Forest Remnant Stand Number
93	r2
84	b28; w41
83	r76
82	(Bell Hill scenic reserve); b3
81	b17; w32
75	b8; w19; r15
74	w34
71	b30; r24; r78; r102; r105
70	w37; r54; r103
69	b29; b31; b32; w38; w40
68	b4; w4; r7
67	b10; r5; r58
66	b16
65	b7; w33; r38
64	b1; b20; w5; r4; r44
63	r1; r40; r65
62	b13; r8
61	w20
60	w29; r34; r43
59	w2; w9; w26; r59; r81
58	w12; w13
57	w30
56	b22; w21; r3; r25; r37; r53; r89; r106; r108
55	w11; r13; r85; r97
54	w27; r49; r80; r94
52	b2; r6; r35
51	w18
50	b9; b11; w6; w50; r16; r52; r57; r75; r82; r86
49	w15; w16
47	r18
46	b15; b26; w43; w46; w60; r29; r62; r63; r79; r93; r104
45	b5; b6; b12; b19; w10; w23; w31; w56; w58; r11; r19; r22; r23; r83; r84; r87; r90; r107
44	b25; b33; w17; w42; w55
42	r14; r61
41	b34

C.S.I. Value	Forest Remnant Stand Number
40	b14; b18; w1; w7; w14; w59; w61; r33; r47; r48; r72; r73
39	r74; r88
35	b21; b23; b24; b27; w3; w8; w35; w39; w44; w47; w48; w51; w52; w53; w54; w62; r12; r26; r27; r36; r46; r50; r60; r64; r66; r70; r71; r77; r91; r92; r95
30	w36; w57; r21; r32; r67; r68; r69
25	w45; r9; r10; r30; r39; r41; r42; r45; r51; r55; r56; r96
20	w22; w24; w25; w28; r20; r28; r31; r98; r99; r100; r101
19	r17

Appendix 7: Forest Remnant Inventory Data

For each forest remnant, this Appendix presents:

(a) Stand Number

(b) Area

(c) Landform

(d) Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy, Species[2]

(e) Modification[3]

(f) Birds[4]

(g) Conservation Status Ranking and Index[5]

(h) Notes

Notes :

1. Area (in hectares) was measured using a planimeter on the forest remnant vegetation maps (Figures 14, 15 and 16). Figures for b32, b33 and b34 were from aerial photographs.
2. Species are listed in approximate decreasing order of abundance.
3. The following system of assessing and grading the degree of modification is used:

	CANOPY	UNDERSTOREY
A.	Intact	Intact to slightly modified
B.	Intact	Modified to eliminated
C.	Modified	Intact to slightly modified
D.	Modified	Modified to eliminated
E.	Eliminated	Modified

Where there is more than one plant community per remnant, there may be more than one assessment of modification recorded. Plant communities without specific assessments are covered by the immediately preceding assessment.

4. The number of forest dwelling native species recorded during the field survey is noted. Figures for forest remnants on Blairs block and elsewhere surveyed during the winter of 1980 are denoted by an asterisk (*).
5. The letters refer to the orders of rank ascribed to each remnant on the four ecological criteria used in assessing conservation status (refer Table 6). Where there is more than one community per forest remnant, the fourth criterion, the number of forest bird species, is listed with the first community. Second and subsequent communities have three letters only. Data for number of bird species in some remnants was not available. These remnants also have three letters only.

Symbols used:

a. Parentheses ( ): indicates that the species or set of species enclosed is of minor importance within the vegetation layer indicated (less than 10-20%).

b. Brackets [ ]: indicate a very open vegetation layer (less than 20% ground projection coverage). If used on the top layer, trees listed are emergents; if used on the second layer, trees specified are sub-canopy and relatively sparse. If not used, the community structure lies somewhere between these extremes.

c. Semi-colon ; : separates the top two vegetation layers, usually emergents from canopy or canopy from sub-canopy.

d. Question mark ? : indicates uncertainty in assessment of specified feature.

Abbreviations used

2^{o}	:	secondary - usually secondary regrowth consequent upon logging, fires, etc.
n.d.	:	no data available
d.b.h.	:	diameter at breast height
N, NW, SW, S, SE, E, NE	:	points on the compass
RB	:	red beech
MB	:	mountain beech
SB	:	silver beech
RBxMB	:	red beech-mountain beech hybrid
Kh	:	kahikatea
H. totara	:	Halls totara
S. rata	:	southern rata
tce	:	terrace
c	:	*circa* (around)

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status		Notes
						Ranking	CSI	
b1	10.7	a. Loopline outwash tce	B1: rimu, Kh, (miro, H. totara, cedar); 2°Kh, kamahi, toatoa, manuka	D, heavily logged, shrub parts, grazed	6	ADD:C	64	
		b. Narrow degradational alluvial tce along Piper Ck	A4: Kh, matai, rimu, miro; 2°Kh, toatoa, kamahi, marbleleaf, broadleaf, 2°rimu					
b2	0.4	Aggrading alluvial fan derived from adjacent Tertiary hill country, overlying glacial outwash gravels	A3: Kh; 2°Kh	D, logged but regenerating profusely, heavily grazed	4	AFDC	52	
b3	37.5	Moderately steep low Tertiary sandstone and siltstone hill slopes; scllfluction deposits at base of hills and alluvium in some gullies	D1v: rimu, miro, (Kh); kamahi, pokaka, quintinia, S. rata, (hinau, H. totara, toro, toatoa, marbleleaf)	A, wild animals (goat, red deer)	10	CBA:B	82	Principally a Crown Land block adjacent to Mawhera forest, completely fenced off from rest of Blairs block; virgin forest primarily on upper slopes and ridges; former gold-workings evident N of large clearing (S44:936843)
			D1: [rimu, miro, (Kh)]: kamahi, quintinia, S. rata, 2°Kh, 2°rimu, pokaka, (hinau, H. totara, toro, toatoa, marbleleaf)	C, heavily logged, wild animals		CCC		
b4	26.0	Loopline outwash tce, overlain in E by thin alluvium veneer derived from adjacent Tertiary hill country	B1: [Kh, (rimu, miro)]; 2°Kh, 2°rimu, kamahi, toatoa, (broadleaf, marbleleaf)	D, heavily logged, grazed	6	ABDC	68	Clearly visible haul lines suggest more recent (?re-) logging
b5	0.3	Loopline outwash tce, overlain by thin alluvium veneer derived from adjacent Tertiary hill country	B1: [Kh, rimu]; 2°Kh	D, heavily logged and grazed	0	AFDD	45	Eight fernbirds recorded in pakihi around b5, b6, and adjacent parts of b4
b6	0.3	Loopline outwash tce, overlain by thin alluvium veneer derived from adjacent Tertiary hill country	B1: [Kh, rimu]; 2°Kh	D, heavily logged and grazed	1	AFDD	45	
b7	11.0	Degradational alluvial tce system along Piper Ck	A4: rimu, Kh, miro, (matai, cedar, H. totara]; 2°Kh, 2°rimu, toatoa, kamahi, marbleleaf, manuka	D, logged (heavily in parts), shrub margins, grazed, weeds	8	BCDB	65	Single RB pole 6-8 m high, c.12 cm dbh, on alluvial terrace immediately above Piper Creek (S44:924833)

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Notes
b8	6.5	Slight degradational alluvial tce along Piper Ck	A4: rimu, Kh,miro, (cedar); 2°Kh, toatoa, 2°miro, marbleleaf, kamahi, manuka	D, logged (heavily in parts), shrub margins, grazed	8	BDD:B	75	Beech outlier area small, confined to W end; isolated RBxMB tree in SE corner (S44: 936826)
			A5: RB, rimu, miro, Kh, (RBxMB); [broadleaf, toatoa]	B, lightly logged, heavily grazed,weeds		AED		
b9	2.0	Loopline outwash tce gravels, overlain by thin veneer of alluvium/colluvium derived from adjacent Tertiary hill country	B1: [rimu, miro]; 2°Kh, (toatoa, kamahi, silver pine, broadleaf, marbleleaf)	D, heavily logged and grazed	1	AEDD	50	Vegetation patchy; 1 fernbird recorded in vicinity
b10	31.9	a. Steep hill slopes downcut by river into Loopline outwash tce, plus gully	C1: rimu, miro, (Kh); kamahi, quintinia, pokaka, wineberry, 2°Kh, 2°rimu, (marbleleaf, mahoe, fuchsia)	C, logged, lightly grazed, farm track (old tramline) through centre	7*	CBC: C	67	*Dicksonia fibrosa* (wheki-ponga) common on Arnold River terrace
		b. Alluvial tce adjacent to Arnold River	A3: [miro]; 2°Kh, kamahi, (marbleleaf)	D, heavily logged and grazed,weeds		ADD		
b11	1.5	Loopline outwash tce	B1: rimu, Kh, (miro); 2°Kh, 2°rimu, kamahi, toatoa, (quintinia, broadleaf, silver pine)	D, heavily logged and grazed,bisected by drain	1	AEDD	50	
b12	0.1	Loopline outwash tce	B1: 2°Kh	D, heavily logged and grazed	0	AFDD	45	Small clump of trees only
b13	8.2	a. Steep slope between Loopline outwash tce flights	C1: [rimu, miro]; 2°rimu, kamahi, quintinia, (2°Kh, toatoa, broadleaf, marbleleaf, wineberry)	D, heavily logged and grazed, bisecting fence in W	n.d.	CED	62	
		b. Loopline outwash tce	B2: rimu, (miro, Kh); 2°rimu, toatoa, kamahi, 2°Kh, quintinia			AED		
b14	4.6	Hill slope between Loopline outwash tce flights	C1: [rimu, miro]; 2°rimu, kamahi, quintinia, (broadleaf, toatoa, marbleleaf, wineberry)	D, heavily logged and grazed; farm track and bisecting fence	1	CEDD	40	
b15	2.2	Steep hill slope between Loopline outwash tce flights	C1: [miro, rimu, (Kh)]; kamahi, wineberry, pokaka, 2°Kh, 2°rimu, (marbleleaf)	D, heavily logged, partly burnt(?), heavily grazed, semi-overgrown farm track	5	CEDC	46	
b16	20.5	a. Tertiary sandstone and siltstone rise, partly overlain by Loopline glacial outwash gravels	C1: rimu, miro; kamahi, quintinia, pokaka, S. rata, (hinau, toro, marbleleaf)	C, logged, shrub margins, lightly grazed	5	CDC:C	66	Generally only lower slopes logged; some recent tree fern cutting in SE

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Notes
		b. Bottom slopes of Tertiary sandstone and siltstone formations	Dl: [rimu, miro]; kamahi, marbleleaf, pokaka, fuchsia, 2^{o}Kh			CDC		
			Dlv: rimu, miro; kamahi, quintinia potaka, S. rata, marbleleaf	A, wild animals		CEA		
b17	42.0	Moderately steep low Tertiary sandstone and siltstone hill ridges and slopes, plus narrow gully	Dl: [rimu, miro];kamahi, marbleleaf, wineberry, quintinia, pokaka, S. rata	C, heavily logged, shrub margins, wild animals (red deer)	10	CEC:B	81	Fenced off from rest of Blairs block; small areas of old regeneration within Dlv community not mapped out; tunnel (S44: 954808) and other workings (S52:952816) evidence of former gold-mining activity
			Dlv: rimu, miro; kamahi, pokaka, S. rata, pokaka, toro	A, wild animals		CBA		
b18	3.1	Small Tertiary sandstone siltstone formation rise, surrounded by Loopline outwash tce	Dl: rimu, miro; kamahi, quintinia, pokaka, S. rata, toro, marbleleaf	D, logged, shrub margins, grazed	2	CEDD	40	
b19	0.4	Loopline outwash tce; small creek bisects stand	B6: RB, (MB, Kh, rimu)	D, logged, heavily grazed, sprayed, margins bissected by fence	2*	AFDD	45	Beech in b19 and eastern part of b20 now outliers but probably once joined to beech stands towards Arnold River; beech stumps in vicinity indicate beech formerly more widespread on Loopline terrace here
b20	22.2	Loopline outwash tce; small creek bisects stand	B6: RB, (MB, Kh, rimu); toatoa, 2^{o}Kh, 2^{o}RB, kamahi, broadleaf	D, heavily logged and grazed, sprayed margins, bisected by fences	4*	CED:C	64	Canopy layer practically eliminated from parts of B3 community; several shrub patches of manuka, gorse, and *Coprosma* spp. within stand but young regeneration also evident
			B5: MB			DFD		
			B3: Kh, rimu, (cedar, matai, H. totara); 2^{o}Kh, toatoa, 2^{o}rimu, silver pine, manuka, (broadleaf, wineberry)			BCD		
			E2: manuka, gorse	E, grazed, partly sprayed		EEE		
b21	0.8	Loopline morainic ridge	Cl: [miro, Kh], kamahi, quintinia, pokaka, (2^{o}Kh)	D, heavily logged, grazed	2*	CFDD	35	Three fernbirds recorded to N and W; gold mining pit and water race adjacent to road
b22	5.2	a. Tertiary sandstone and siltstone ridge and steep slopes	Dl: [miro, rimu]; kamahi, quintinia, pokaka, (marbleleaf, fuchsia)	D, logged, grazed	4*	CED:C	56	Fenced along roadside and Deep Creek; remains of Kotuku-Notown pack track on Deep Creek edge
		b. Deep Creek alluvial plain	A5: RB	B, lightly logged, grazed		CFB		
b23	0.8	Slight Loopline morainic slope	Cl: rimu, miro, Kh; kamahi, quintinia, marbleleaf, (2^{o}Kh, 2^{o} rimu)	D, logged, heavily grazed, weeds	0*	CFDD	35	

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Notes
b24	0.9	Loopline morainic slope; S aspect	Cl: [rimu, miro]; kamahi, marbleleaf, quintinia, (2°Kh)	D, heavily logged and grazed	2*	CFDD	35	
b25	9.8	Loopline morainic slope	Cl: miro, rimu, Kh; kamahi, 2°Kh, marbleleaf, quintinia, 2°rimu, toatoa	D, logged, heavily grazed	2*	CDDD	44	Variable community, with patches of dense sapling and pole 2°Kh, and extensive shrub margins on S edge; 3 fernbirds recorded in vicinity
b26	2.9	Loopline morainic ridge and slopes	Cl: [miro]; kamahi, quintinia, marbleleaf, 2°miro	D, logged, grazed	4*	CEDC	46	One fernbird recorded in vicinity; 2-3 m wide transect cuts through obliquely
b27	0.7	Rolling Loopline morainic hill country	Cl: [miro, rimu]; kamahi, 2°rimu, quintinia, 2°miro, 2°Kh, toatoa, broadleaf	D, logged, heavily grazed, sprayed	3*	CFDD	34	Much of b27 dying from spraying of surrounding gorse; 2-3 m with transect cuts through obliquely
b28	54.9	a. Arnold River alluvial terrace, very swampy	A3: Kh, (matai); 2°Kh, toatoa *Coprosma* spp.	D, heavily logged, grazed (?)	8*	ADD:B	84	Considerable variation in Cl community, including some shrub patches with much 2°Kh; SE boundaries unfenced, and small areas excluded from recently installed fence; one fernbird recorded between b28 amd b29
		b. Arnold River alluvial terrace, well drained	A2v: Kh, matai; kaikomako, marbleleaf, wineberry, *Coprosma rotundifolia*	A, lightly grazed		ADA		
		c. Loopline morainic ridges and slopes, plus gully	Cl: rimu, miro, Kh, (cedar, matai); kamahi, quintinia, marbleleaf, 2°rimu, toatoa, 2°Kh, pokaka	D, heavily logged, formerly grazed, gorse along old logging tracks, wild animals		CAD		
b29	23.4	a. Loopline morainic ridges and slopes	Cl: rimu, miro; kamahi, toatoa, quintinia, 2°rimu, 2°Kh, pokaka, 2°rimu	D, recently heavily logged, formerly grazed, sprayed margins, wild animals	8*	CBD:B	69	Multiplicity of logging tracks indicate recent (?re-) logging; forest regenerating well but some gorse present on logging tracks; new Farm Settlement boundary fence erected around N edge; 5-6 m wide transect recently cut through b29, extends into adjacent Arnold River scenic reserve
		b. Terrace within Loopline morainic hill country	B2: rimu; kamahi, toatoa, quintinia					
b30	69.5	a. Alluvial terrace within gully, opening onto Arnold River terrace	A2: Kh, (RB, matai, cedar); 2°Kh, wineberry, marbleleaf, 2°RB	D, heavily logged, grazed	7*	AED:C	71	Vegetation within b30 highly variable, reflecting beech invasion patterns, landform and modification variations; RB stumps on NW side suggest beech formerly more widespread; some tree mortality from spray drift; stand bisected by farm track; roughly formed overgrown vehicle
		b. Alluvium in gully bottom and surrounding gully slopes	A5: RB, (Kh); (marbleleaf, kamahi, wineberry, toatoa)			CED		
		c. Steep slopes between Arnold River tce and Loopline outwash tce, and steep gully slopes	Cl: rimu, miro; kamahi, marbleleaf, quintinia, pokaka, 2°rimu, toatoa	D, heavily logged, varied grazing		CCD		

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Notes
b30 (cont.)		d. Loopline outwash tce	B6: RB, MB, (rimu, Kh); (2°RB, kamahi, toatoa, 2°rimu)	B, logged for for podocarps(?), grazed		CCB		track on legal road along Arnold River N bank between b30 and b30; old tramline along N edge of b30
			B5: MB, toatoa, (RB, pink pine)			DEB		
			B2: [rimu, Kh, cedar]; kamahi, toatoa, 2°rimu, wineberry, marbleleaf, *Coprosma* spp., silver pine, 2°Kh	D, heavily logged, grazed, shrub patches		ACD		
			B1: [miro, rimu, Kh]; 2°Kh, kamahi, 2°rimu, toatoa, marbleleaf, wineberry			ADD		
			B4: toatoa, silver pine, cedar, (2°Kh)	D, logged(?), historically burnt (?), lightly grazed		DCD		
			E1: manuka, pink pine, toatoa, 2°RB	E, grazed		DFE		
b31	8.1	a. Arnold River alluvial terrace	A5: RB, (Kh, matai); [kamahi]	B, logged for podocarps(?), grazed		CDB	69	
		b. Arnold River alluvial terrace, very swampy	A3: Kh; 2°Kh, kamahi	D, heavily logged, grazed(?), partly sprayed		AED		
b32	55.1	Degradational alluvial tce system, cut by Piper Ck into adjacent Loopline outwash terrace	A5: [RB, rimu, miro, (Kh, matai, cedar, H. totara)]; 2°RB, 2°Kh, kamahi, toatoa, (2°rimu)	D, logged (heavily in parts), partly burnt, grazed (stock plus goats)	9	CADB	69	Vegetation patchy and highly variable; haul lines and logging tracks suggest more recent (?re-) logging; burnt RB stumps indicate wider former extent of beech; 6 fernbirds recorded on N edges
b33	6.2	a. Loopline outwash tce, dissected by small stream	B5: MB, (RB, rimu)	D, logged, shrub margins, grazed (stock plus goats)	3	DED:D	44	One fernbird recorded in vicinity
		b. In W, down-cut valley and alluvial terrace	A5: RB, (rimu); [toatoa, broadleaf, wineberry, marbleleaf)			CED		
b34	3.8	Loopline outwash terrace gravels, dissected by small streams	B5: [RB, rimu, Kh]; 2°MB, 2°RB, 2°Kh, 2°rimu	D, logged, shrub margins, heavily grazed	7	DED:C	41	Remnant consists of patches of predominantly MB and RB re-generation interconnected by gorse and shrub vegetation; 2 fernbirds recorded in vicinity

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Notes
w1	0.4	Deep Ck alluvial plain	A4: [miro]; 2^{o}Kh, kamahi, (wineberry, marbleleaf)	D, heavily logged and grazed	1	BFDD	40	Vegetation relatively open
w2	5.1	a. Moana outwash tce remnant b. Moana (lower) and Loopline (upper) morainic hill slopes	B1: 2^{o}Kh, (marbleleaf, kamahi) C1: [rimu, miro]; marbleleaf, kamahi, broadleaf, (2^{o}Kh, 2^{o}rimu, wineberry, mahoe)	D, heavily logged, shrub margins, grazed	4	AED:C CED	59	Coldwater spring flush zone near bottom of hill; 1 fernbird recorded on E edge
w3	0.5	Loopline morainic hill slope	C1: [miro]; kamahi, 2^{o}Kh, (mahoe, wineberry, 2^{o}rimu)	D, heavily logged, grazed	1	CFDD	35	
w4	17.7	a. Loopline outwash tce b. Alluvial tces within and upstream of Deep Ck gorge c. Loopline morainic slopes, and steep down-cut slopes above Deep Ck gorge: some Tertiary rocks exposed in gorge.	E1: toatoa, kamahi, quintinia, 2^{o}Kh, 2^{o}rimu A5: RB; [2^{o}RB, 2^{o}Kh, broadleaf, marbleleaf] C1: [rimu, miro, (Kh)]; kamahi, quintinia, toatoa, marbleleaf, toro, kaikomako, broadleaf, C1v: rimu, miro, (Kh); kamahi, quintinia, hinau, toatoa, marbleleaf	E, grazed C, logged (heavily in parts), shrub margins, grazed, wild animals (red deer, goats) A, apparently unlogged, lightly grazed(?)	7	DEE:C CEC CDC CEA	68	Virgin community located on steep slopes above upper part of Deep Ck gorge; 2 fernbirds recorded on upper terrace; gold(?-)-sluicing face on E slope at lower end of Deep Ck gorge
w5	17.3	a. Loopline morainic ridge and slopes b. Loopline outwash tce	C1: [miro, rimu, (Kh)]; kamahi, quintinia, toatoa, 2^{o}rimu, 2^{o}Kh, (pokaka, marbleleaf, broadleaf) B1: [Kh, rimu]; 2^{o}Kh, toatoa, kamahi, 2^{o}rimu, (silver pine, pink pine)	D, logged, grazed	6	CCD:C ADD	64	One fernbird recorded in vicinity; w5 & w6 separated by recently constructed fenceline
w6	5.5	Slight Loopline morainic ridges and slopes	C1: [rimu, miro (Kh)]; kamahi, quintinia, toatoa, 2^{o}Kh, 2^{o}rimu, (H. totara, broadleaf)	D, logged, grazed, bulldozed farm tracks on E & W edges	4	CDDC	50	Bisected by overgrown tramline
w7	2.2	Loopline morainic slope	C1: [miro, rimu, Kh]; kamahi, marbleleaf, 2^{o}Kh, broadleaf, mahoe	D, heavily logged, shrub parts, grazed	2	CEDD	40	
w8	0.5	Loopline morainic slope	C1: [rimu, miro]; quintinia, kamahi, broadleaf, marbleleaf, 2^{o}Kh, 2^{o}rimu	D, heavily logged, shrub margins, grazed	1	CFDD	35	One fernbird recorded in vicinity

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Note
w9	3.1	a. Loopline morainic ridge and slope b. Loopline outwash tce	C1: miro, rimu; kamahi, toatoa, quintinia, 2^{o}rimu B1: [Kh, rimu]; 2^{o}Kh, 2^{o}rimu, toatoa, (kamahi)	D, heavily logged, grazed	6	CED:C AED	59	One fernbird recorded on E edge
w10	0.2	Loopline outwash tce	B1: [rimu, Kh, miro]; 2^{o}Kh, (broadleaf, toatoa)	D, heavily logged and grazed, intruding drain	2	AFDD	45	One fernbird recorded in vicinity
w11	0.5	Loopline outwash tce	B2: rimu, (Kh, cedar, miro); [kamahi, toatoa, 2^{o}Kh]	B, lightly logged, grazed	1	AFBD	55	
w12	22.8	Degradational alluvial tce system incised by Deep Ck	A5: RB, (Kh, matai, rimu); 2^{o}RB, (2^{o}Kh)	D, logged (podocarps plus beech), burnt, grazed, vehicle track through length of w12	7	CBDC	58	Patches of shrub, hardwood, and RB pole regeneration; burnt RB stumps over most of lower tces; recently constructed fence isolates part of stand; gold(?)-sluicing race (S51:986800)
w13	5.1	a. Loopline outwash tce b: Deep gully incised into outwash tce, plus steep slopes between outwash and Deep Ck alluvial tces	E2: maunka, (Kh, rimu) C1: rimu, miro, (cedar, Kh); kamahi, quintinia, marbleleaf, toatoa, broadleaf, wineberry	E, grazed, B, lightly logged(?) grazed	6	EEE:C CEB	58	One fernbird recorded on W side
w14	1.3	Steep slopes between Deep Ck alluvial tce and Loopline outwash tce	C1: miro, rimu, Kh; kamahi, quintinia, toatoa, marbleleaf, (wineberry, 2^{o}Kh)	D, logged, grazed	3	CEDD	40	Two fernbirds recorded in vicinity on upper terrace
w15	4.0	Loopline outwash tce	E2: manuka, *Coprosma* spp. E1: toatoa, kamahi, *Coprosma* spp., 2^{o}Kh B1: Kh, rimu, (cedar); toatoa, 2^{o}Kh, 2^{o}rimu, broadleaf, manuka	E, grazed, drain D, heavily logged, shrub parts, grazed	3	EEE:D DFE AFD	49	One fernbird recorded on W edge
w16	3.1	Deep Ck degradational alluvial tce	A5: RB, (Kh); 2^{o}RB, (kamahi, toatoa, broadleaf) E1: *Coprosma* spp., 2^{o}RB, 2^{o}Kh, 2^{o}rimu toatoa	D, logged, partly burnt, grazed E, grazed	3	CED:C DEE	49	RB pole stands in E, regenerating after fire; SE part of stand isolated by recently constructed fence; burnt RB stumps over most of tce nearby

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Notes
w17	3.3	Deep Ck degradational alluvial tce	A5: RB, (Kh); [2°Kh, gorse]	D, logged(?),partly burnt, grazed	n.d.	CED	44	Patchy red beech community, with some shrub areas
w18	8.8	a. Deep Ck degradational alluvial tces	A5: RB, Kh, rimu, (MB); [2°Kh, 2°RB, 2°MB]	D, logged (varying intensity), shrub	5	CED:C	51	Some parts cut off by new fence-line; 1 fernbird recorded on
		b. Loopline outwash tce	B6: 2°RB, 2°Kh, toatoa, MB, manuka	margins, grazed		CED		S periphery
			E2: manuka	E, grazed		EEE		
w19	45.2	a. Deep Ck degradational alluvial tces	A4: Kh, rimu, (RB, cedar, MB); toatoa, manuka, kanuka	D, logged (beech plus podocarps - varying intensity),	9	BED:B	75	Wide spatial variation within red beech communities, ranging
			A5: RB, (MB, Kh, rimu,miro,cedar)			CBD		from pure dense pole stands to
		b. Loopline outwash tce,& intermediate degradational terrace	B1: [Kh, miro,cedar]; 2°Kh, manuka, toatoa, *Coprosma* spp.,(2°rimu)	shrub margins (and elsewhere), grazed,		AED		complex mixtures with other species; re silver beech stand,
			B4: toatoa, pink pine, silver pine, cedar, kamahi, MB, (RB)	wild animals (red deer)		DDD		see community description (Section 2.5.4.3); stand bisected
			B6: RB, MB, (Kh, cedar); toatoa, pink pine, silver pine, 2°RB, 2°MB			CCD		by overgrown tramline; now entirely fenced off from rest of Weka block
			B7: SB, (RB, MB)	B, grazed		AFB		
w20	4.2	a. Loopline outwash tce	B1: rimu, Kh, (H. totara, cedar); kamahi, toatoa, manuka, (2°Kh, 2°rimu, 2°miro)	D, heavily logged, grazed	5	AED:C	61	Two fernbirds recorded in vicinity
			E2: manuka, *Coprosma* spp., (toatoa, 2°Kh, 2°rimu)	E, grazed		EEE		
		b. Deep gully incised into outwash tce, plus steep slopes between outwash and Deep Ck alluvial tces	C1: rimu, miro, Kh; kamahi, marbleleaf, broadleaf, (wineberry, fuchsia, H. totara)	B, lightly logged (?), grazed		CEB		
w21	4.0	Loopline outwash tce	B1: [rimu, Kh, miro]; kamahi, broadleaf, toatoa, quintinia, 2°Kh, manuka	D, heavily logged, extensive shrub margins, grazed, farm drains	4	AEDC	56	
w22	0.7	Loopline outwash tce	E2: manuka, *Coprosma* spp., (2°Kh, 2°rimu, toatoa	E, grazed	1	EFED	20	
w23	0.5	Loopline outwash tce	B1: rimu, Kh, miro, (cedar, H.totara, silver pine); toatoa, kamahi, 2°Kh, manuka	D, logged, shrub margins, grazed, bisected by drain	3	AFDD	45	

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w24	0.2	Loopline outwash tce	E2: manuka, gorse, (blackberry, 2°Kh, toatoa)	E, grazed	1	EFED	20	Two fernbirds recorded in vicinity
w25	0.2	Loopline outwash tce	E2: manuka, *Coprosma* spp., (blackberry, cedar, rimu, H. totara, 2°Kh)	E, grazed	0	EFED	20	
w26	15.1	Loopline outwash tce	E2: manuka, *Coprosma* spp., (2°Kh, toatoa)	E, grazed, intruding new track and drains	5	ECE:C	59	Five fernbirds recorded in vicinity
			B1: rimu, Kh, (cedar, miro); kamahi, toatoa, manuka, 2°Kh, (silver pine)	D, heavily logged, recently burnt on N margins, grazed		AED		
w27	2.3	Loopline outwash tce	E2: manuka, *Coprosma* spp., (blackberry, 2°Kh)	E, grazed	4	EEC:C	54	One fernbird recorded in vicinity
			B1: rimu, Kh; 2°Kh, toatoa	D, logged, grazed		AFD		
w28	0.2	Loopline outwash tce	E2: manuka, *Coprosma* spp., (blackberry, rimu, 2°Kh, kamahi, broadleaf, wineberry)	E, grazed	2	EFED	20	
w29	1.1	Loopline outwash tce	B2v: rimu, (cedar, Kh, miro); [kamahi, toatoa, quintinia]	B, shrub margins, grazed	2	AEBD	60	
w30	7.7	Loopline outwash tce	B3: [rimu, Kh, (cedar)]; toatoa, kamahi, pink pine, silver pine, 2°rimu, manuka	D, logged, recently burnt margins, lightly grazed, drain on E edge	5	BDD:C	57	One fernbird recorded in vicinity
			E2: manuka, (cedar, toatoa)	E, grazed		EEE		
w31	1.4	Loopline outwash tce	B3: [rimu, Kh, (cedar)]; toatoa, kamahi, 2°Kh, pink pine, silver pine, manuka	D, logged, burnt margins (recently on N edge), grazed	1	BEDD	45	
w32	28.1	Loopline outwash tce	B2v: rimu, (miro, cedar, Kh); kamahi, quintinia, toatoa, (broadleaf, pink pine, silver pine, H. totara)	B, grazed, shrub margins, intruding drains	8	ADB:B	81	One S. rata seedling in B2v community; short no-exit drains near road causing local ponding and vegetation die-off; 3 fernbirds recorded on NW edge
			B1v: rimu, Kh, (cedar); [kamahi, toatoa, broadleaf]			AEB		
			B1: rimu, Kh, (cedar); kamahi, toatoa, 2°Kh, 2°rimu, (silver pine, pink pine, manuka)	D, heavily logged, shrub margins, grazed		ACD		
			B2: [rimu]; toatoa, kamahi, 2°rimu, broadleaf, quintinia			ADD		
			E2: manuka, *Coprosma* spp., (toatoa, pink pine, silver pine)	E, grazed		EEE		

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status		Notes
						Ranking	CSI	
w40	40.0	Loopline morainic ridge and slopes; S aspect predominant	C1: [rimu, miro, (Kh)]; kamahi, marbleleaf, quintinia, 2°rimu, broadleaf, wineberry, pokaka, toatoa	D, logged, shrub margins, grazed (heavily outside N fence)	8	CADB	69	Entirely fenced off from rest of Weka block, except for small area on N periphery
w41	34.0	a.Loopline morainic slopes b. Flat tce between morainic slopes (dissected by gully in S)	C1: [rimu, miro]; quintinia, kamahi B2: [rimu, (miro, Kh)]; 2°Kh, toatoa, *Coprosma* spp. B2v: rimu, (miro, cedar, Kh); [kamahi, quintinia, toatoa, broadleaf, S. rata]	D, heavily logged, shrub margins, grazed A, lightly grazed (cattle)	7	CDD:C AED ABA	84	Entirely fenced off from rest of Weka block; vegetation patchy in B2 community
w42	5.5	Loopline morainic ridges and slopes	C1: [rimu, miro]; kamahi, quintinia, 2°rimu, broadleaf, marbleleaf, toatoa	D, heavily logged, shrub margins, heavily grazed, weeds	3	CDDD	44	
w43	4.2	Loopline morainic slopes	C1: [rimu, miro]; kamahi, quintinia, 2°rimu, broadleaf, toatoa, pokaka	D, heavily logged, shrub margins, heavily grazed, weeds	5	CEDC	46	Several S. rata trees; 1 fernbird recorded in vicinity
w44	0.2	Loopline morainic slope; S aspect predominant	C1: [miro]; kamahi, broadleaf, quintinia, 2°rimu	D, heavily logged, shrub margins, heavily grazed, weeds	1	CFDD	35	
w45	1.6	Loopline morainic slope	E2: *Coprosma* spp., (2°Kh, 2°rimu, broadleaf)	E, grazed, weeds	1	EEED	25	
w46	4.0	Loopline morainic ridge and slopes; S aspect predominant	C1: [rimu, miro]; kamahi, quintinia, toatoa, 2°rimu, marbleleaf, broadleaf	D, heavily logged, shrub margins, heavily grazed, weeds	6	CEDC	46	
w47	0.2	Low Loopline morainic ridge	C1: [miro]; kamahi, broadleaf, 2°rimu	D, heavily logged, shrub margins, heavily grazed, weeds	0	CFDD	35	Small clump of trees only
w48	0.3	Loopline morainic ridge and slopes	C1: [rimu]; kamahi, quintinia, toatoa, 2°rimu, marbleleaf, broadleaf	D, heavily logged, shrub margins, heavily grazed, weeds	2	CFDD	35	

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						Ranking	CSI	
w49	0.4	Loopline morainic slope	Cl: [rimu]; kamahi, quintinia, 2°rimu, 2°miro	D, heavily logged, extensive shrub margins, heavily grazed, weeds	1	CFDD	35	
w50	6.7	Loopline morainic ridge and slopes	Cl: [rimu, miro]; quintinia,kamahi, 2°rimu, toatoa, toro	D, heavily logged, shrub margins, grazed	4	CDDC	50	
w51	0.3	Loopline morainic slope; S aspect	Cl: [rimu, miro]; kamahi, quintinia, toatoa, 2°rimu	D, heavily logged, extensive shrub margins, heavily grazed, weeds	2	CFDD	35	
w52	0.5	Loopline morainic slope	Cl: [miro, rimu]; quintinia,kamahi, toro, 2°miro, 2°rimu	D, logged, shrub margins, grazed	3	CFDD	35	
w53	0.3	Loopline morainic slopes	Cl: [rimu, miro]; kamahi, quintinia, 2°rimu, 2°miro, toatoa,broadleaf	D, logged, shrub margins, heavily grazed, weeds	1	CFDD	35	
w54	0.6	Loopline morainic slope, grading onto poorly drained tce	Cl: [rimu, miro, cedar]; kamahi, toatoa, manuka, (quintinia, silver pine, pink pine)	D, logged, grazed	3	CFDD	35	
w55	9.7	Low Loopline morainic ridges and slopes	Cl: [miro, rimu]; kamahi, quintinia, 2°rimu, toatoa, broadleaf, wineberry	D, logged, shrub margins, grazed	2	CDDD	44	One S. rata tree; stand extensively damaged by wide bisecting fenceline
w56	0.2	Loopline outwash tce, poorly drained	B2: rimu, (Kh); [toatoa, kamahi, 2°rimu, broadleaf]	D, heavily logged, grazed, weeds (oversowing)	1	AFDD	45	
w57	0.5	Depression on Loopline outwash tce, bisected by small stream	B4: pink pine, toatoa, silver pine, manuka	D, heavily logged (?), extensive shrub margins,heavily grazed, weeds	1	DFDD	30	
w58	0.9	Loopline morainic toe-slope, grading onto outwash tce	B6: [miro]} 2°RB, 2°MB, RBxMB, manuka	D, logged(?), extensive shrub margins, heavily grazed, weeds	3	AFDD	45	An anomalous beech outlier, possibly formerly connected to Deep Ck stands; currently a central stand plus two E outliers, inter-connected by shrublands

Stand No.	Area (ha)	Landforms	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status		Notes
						Ranking	CSI	
w59	0.2	Loopline outwash tce, poorly drained	Bl: 2^{o}Kh, (2^{o}rimu, manuka)	E, historically burnt, grazed	0	AFED	40	
w60	2.5	Low Loopline morainic ridges and slopes	Cl: [rimu, miro, Kh]; kamahi, quintinia, 2^{o}rimu, toatoa, broadleaf, 2^{o}Kh	D, logged, shrub margins, heavily grazed	4	CEDC	46	
w61	1.5	Loopline morainic slopes; S aspect	Cl: [rimu, miro]; kamahi, 2^{o}rimu, quintinia, H. totara, toatoa, broadleaf	D, logged, shrub margins, heavily grazed	2	CEDD	40	
w62	0.2	Loopline morainic ridge	Cl: kamahi, 2^{o}rimu, marbleleaf, toatoa, wineberry, broadleaf	D, heavily logged and grazed	0	CFDD	35	

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-Canopy Species	Modification	Birds	Conservation Status Ranking CSI	Notes
r1	9.2	a. Deep Ck degradational alluvial tce	A5: RB, (Kh, cedar, MB, matai); [toatoa, kamahi, pink pine]	B, lightly logged (?), grazed	9	CDB:C 63	Charred beech stumps on S edge indicate beech formerly more extensive; 2 fernbirds recorded on S edge (winter 1980); r1 now now entirely fenced off from Ruru block.
		b. Loopline outwash tce	B5: MB, RB, (rimu); kamahi, toatoa, 2^{o} RB, manuka	D, logged, extensive shrub margins, grazed		DED	
r2	61.0	a. Deep Ck degradational alluvial tce	A5: RB, (Kh, rimu, cedar, miro, matai, MB, RBxMB); [kamahi, marbleleaf, 2^{o}RB, broadleaf]	A, lightly logged, lightly grazed	11	CAA:A 93	Considerable variation in A3 community (including open and shrub patches) and A5 community (including a regenerating pole stand in NW); clearly visible haul lines in N suggest recent (?re-) logging; 5-6 fernbirds recorded in Deep Ck pakihi on NW edges; robin and rifleman also recorded; r2 separated from adjacent ecological area in Mawhera State forest by recently constructed road which has caused some damage to r2 vegetation; r2 entirely fenced off from rest of Ruru block.
			A3: [Kh, miro, rimu]; 2^{o}Kh, *Coprosma* spp., kamahi, 2^{o}RB	D, heavily logged, shrub parts, grazed		AED	
		b. Loopline outwash tce	B2: rimu, (Kh, miro); 2^{o}Kh, kamahi, toatoa, 2^{o}RB	D, heavily logged, shrub margins, grazed		AFD	
			B2v: rimu, (Kh, miro, RB, cedar); [kamahi, quintinia, 2^{o}RB]	A, lightly grazed		AEA	
			B4: [cedar]; pink pine, toatoa, manuka	D, logged, shrub margins, grazed, extensive cedar mortality		DED	
			B5: MB, (RB, rimu, cedar,); [toatoa, kamahi, pink pine, silver pine, 2^{o}Kh, 2^{o}MB]			DED	
			E2: manuka, (kanuka, *Coprosma* spp.)	E, grazed		EEE	
		c. Rolling Loopline outwash tce slopes	C1: [rimu, miro, Kh]; kamahi, quintinia, toatoa, 2^{o}rimu	D, heavily (?re-) logged, grazed		CED	
r3	2.6	Loopline outwash tce	B2: rimu, (miro, Kh); quintinia, kamahi, 2^{o}rimu, 2^{o}Kh, marbleleaf, toatoa, broadleaf	D, heavily logged, shrub margins, heavily grazed, weeds, bisecting drain	6	AEDC 56	
r4	3.7	Loopline outwash tce	B2: rimu, (Kh, cedar); toatoa, kamahi, 2^{o}rimu	D, heavily logged, shrub parts,	10	AFD:B 64	Separated from r2 by recently constructed fence
			B3: Kh, cedar, rimu; toatoa, kamahi, 2^{o}rimu, pink pine			BFD	
			B4: cedar, pink pine, toatoa, manuka			DED	
			E2: manuka	E		EEE	

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r5	10.3	a. Loopline outwash tce	B3: [Kh]; cedar, manuka, pink pine, toatoa, kamahi, silver pine	D, heavily logged, shrub parts,	10	BDD:B	67	B5 beech community almost certainly once contiguous to beech on Deep Ck immediately N
			B5: MB, RB, (RBxMB, cedar, Kh); toatoa, kamahi, manuka, (pink pine)	grazed		DED		
			E1: manuka, kanuka, toatoa, (cedar, pink pine)	E, grazed		DEE		
		b. Narrow alluvial tce along Deep Ck	A5: RB, (miro, rimu, cedar); [toatoa]	B, lightly logged (?), grazed		CFB		
r6	0.7	Loopline outwash tce	B2: rimu, (miro); kamahi, quintinia, 2°rimu, 2°Kh, toatoa	D, heavily logged, shrub margins, heavily grazed, weeds, bisecting drain	6	AFDC	52	
r7	5.4	Loopline outwash tce	B5; MB, MBxRB, toatoa, manuka	D, logged, shrub margins, grazed	6	DFD:C	68	
			B2v: rimu, (miro), [kamahi, quintinia, toatoa]	B, logged margins, heavily grazed		AEB		
			E1: manuka, toatoa, kamahi, quintinia, broadleaf, cedar, pink pine	E, logged, grazed		DEE		
r8	8.1	Rolling Loopline outwash tce	B2: rimu, miro, (cedar); kamahi quintinia, toatoa	B, lightly logged, shrub margins, grazed	3	AEB:D	62	One S. rata tree in B2 community
			B4: cedar, pink pine, toatoa, manuka, silver pine, broadleaf	D, logged, extensive shrub margins, grazed, weeds		DED		
r9	1.3	Slopes about slight depression in Loopline outwash tce, drained by small creek	E2: manuka, *Coprosma* spp., (pink pine, silver pine, toatoa)	E, heavily grazed, weeds, drains	3	EEED	25	
r10	0.6	Low rise on Loopline outwash tce	E1: manuka, kamahi, toatoa, pink pine, cedar	E, grazed	2	DFED	25	
r11	0.8	Low rise on Loopline outwash tce	C1: rimu, (miro); kamahi, quintinia, toatoa, 2°rimu	B, lightly logged, shrub margins, heavily grazed, weeds	2	CFBD	45	
r12	0.4	Low rise on Loopline outwash tce	C1: kamahi, 2°rimu, toatoa, manuka, (cedar, pink pine, silver pine)	D, logged, shrub margins, grazed, weeds, bisecting fenceline	2	CFDD	35	

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r13	2.9	a. Loopline outwash tce	B4: cedar, pink pine, silver pine, toatoa, manuka, 2°rimu	D, logged, extensive shrub margins, heavily grazed, weeds, bisecting fence and track	5	DED:C	55	
		b. Low rise on outwash tce	C1: rimu, (cedar); kamahi, quintinia, toatoa	B, lightly logged (?), heavily grazed, weeds		CFB		
r14	0.3	Low rise on Loopline outwash tce	C1: rimu, miro; kamahi, quintinia, toatoa	D, logged, heavily grazed, weeds	4	CFDC	42	
r15	19.2	Loopline outwash tce	B2v: rimu, cedar, (Kh); toatoa, kamahi, pink pine, silver pine, broadleaf	A, lightly grazed	7	AEA:C	75	Bisecting drain in SW; 1 fernbird recorded on W edge, winter 1980
			B1v: Kh, rimu, (cedar, miro); toatoa, kamahi, (broadleaf)	B, grazed		AEB		
			B1: Kh, rimu, (cedar); toatoa, kamahi, 2°rimu, 2°Kh, (broadleaf, pink pine)	D, logged (varying intensity), shrub margins, grazed		ADD		
			B3: [Kh]: cedar, pink pine, toatoa silver pine, manuka			BED		
			E2: manuka, (toatoa, 2°Kh)	E, grazed		EEE		
r16	2.0	Loopline outwash tce	B1: rimu, Kh; 2°Kh, kamahi, toatoa, quintinia, (pink pine, silver pine)	D, logged, extensive shrub margins, grazed, bisecting drain	2	AEDD	50	
r17	0.3	Loopline outwash tce	E2: manuka, *Coprosma* spp.	E, grazed	n.d.	EFE	19	
r18	0.6	Loopline outwash tce	E2: manuka, *Coprosma* spp.(toatoa, pink pine)	E, grazed	0	EFE:D	47	
			B1: rimu, Kh; 2°Kh, kamahi, toatoa	D, logged, shrub margins, grazed, bisecting drain		AFD		
r19	0.3	Loopline outwash tce	B2: rimu, (Kh); 2°Kh, kamahi, quintinia, (toatoa,broadleaf)	D, heavily logged, shrub margins, grazed	0	AFDD	45	

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r20	0.4	Loopline outwash tce, poorly drained	E2: manuka, (2°Kh, broadleaf)	E, grazed	0	EFED	20	A few Kh and rimu trees
r21	0.4	Poorly drained depression in Loopline outwash tce, bisected by small creek	B4: pink pine, toatoa, silver pine, cedar, manuka	D, logged(?), shrub margins, heavily grazed, weeds	0	DFDD	30	Drain on E edge; tramline along S edge
r22	0.3	Loopline outwash tce	B2: rimu, (Kh, miro, cedar); kamahi, quintinia, toatoa, 2°Kh, broadleaf	D, logged, shrub margins, grazed, bisected by fence	1	AFDD	45	
r23	0.3	Loopline outwash tce	B2: rimu, (Kh, miro); kamahi, toatoa, 2°Kh	D, logged, shrub margins, grazed	0	AFDD	45	
r24	10.8	a. Loopline morainic toe-slope	C1: rimu, miro; kamahi, quintinia, marbleleaf, wineberry, toro	D, logged, shrub margins, grazed	6	CED:C	71	
		b. Loopline outwash tce	B2v: rimu, (cedar, Kh); [kamahi, quintinia, toatoa]	B, heavily grazed, weeds		AEB		
			B2: rimu, miro, Kh, (cedar); kamahi, quintinia, toatoa	D, logged, shrub margins, grazed		AED		
			B3: [Kh]; cedar, pink pine, manuka, toatoa, 2°Kh, (kamahi, H. totara)			BED		
			B1: [Kh]; 2°Kh, (toatoa, kamahi, broadleaf)	E, logged(?), shrub parts		BEE		
r25	3.4	a. Loopline morainic toe-slope	C1: [rimu, miro, Kh]; kamahi, quintinia, toatoa, 2° rimu	D, logged, shrub margins, grazed, weeds	2*	CFD:D	56	N manuka fringes recently flattened by bulldozer
		b. Loopline outwash tce	B3: [Kh, cedar, rimu]; pink pine, 2°Kh, kamahi, toatoa, silver pine			BED		
r26	0.3	Loopline morainic slope	C1: [rimu, miro]; kamahi, toatoa, quintinia, (H. totara, toro, 2°rimu, 2°miro)	D, logged, heavily grazed, weeds	0	CFDD	35	
r27	0.1	Low Loopline morainic ridge	C1: rimu, kamahi, wineberry, H. totara	D, logged, heavily grazed, weeds	0	CFDD	35	Small clump of trees only
r28	0.4	Depression between low Loopline morainic ridges	E2: manuka (blackberry, gorse)	E, grazed	0	EFED	20	
r29	1.3	Loopline morainic slope	C1: rimu, miro, H. totara; kamahi, quintinia, toro, marbleleaf, 2°rimu, 2°miro	D, logged, shrub margins, heavily grazed, weeds	4	CEDC	46	

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r30	0.3	Poorly drained depression between Loopline morainic slopes	E1: manuka, toatoa, kamahi, wineberry cedar, pink pine, Kh, rimu, blackberry	E	0	DFED	25	
r31	0.6	Loopline morainic slopes	E2: manuka	E, grazed	0	EFED	20	
r32	0.2	Small tce below Loopline morainic ridge	C2: [Kh]; 2^{o}Kh, (2^{o}rimu, kamahi)	D, logged, shrub margins, grazed	3	DFDD	30	Prolific tall kahikatea regeneration
r33	1.8	Loopline morainic ridge and slopes	C1: miro, rimu; kamahi, quintinia, toatoa, broadleaf, 2^{o}miro, 2^{o}rimu	D, logged, shrub margins, heavily grazed, bisected by old track	1	CEDD	40	Several S. rata trees
r34	2.0	Loopline outwash tce	B1: Kh, rimu, (miro); [kamahi, quintinia]	B, lightly logged (?), heavily grazed	2	AEBD	60	Tall dense stand of recently mature podocarp trees
r35	0.5	Loopline outwash tce	B2: rimu, (miro, Kh); kamahi, 2^{o}rimu, (toatoa, broadleaf, 2^{o}Kh)	D, heavily logged, shrub margins, heavily grazed, weeds	4	AFDC	52	
r36	0.1	Loopline morainic ridge and slope	C1: rimu; kamahi, marbleleaf, broadleaf, quintinia, 2^{o}Kh	D, heavily logged, shrub margins, heavily grazed, weeds	2	CFDD	35	
r37	8.9	Rolling Loopline morainic hill country	C1: rimu, miro; kamahi, quintinia, toatoa, 2^{o}rimu, (broadleaf, pink pine, silver pine)	D, logged, shrub margins, heavily grazed, weeds, drain on E edge	8	CDDB	56	Variable community, including some dense secondary hardwood pole stands, plus pink pine-silver pine-toatoa-manuka stand in a small poorly drained depression
r38	33.7	Rolling Loopline morainic hill country	C1: rimu, miro, (Kh); kamahi, quintinia, toatoa, 2^{o}rimu, (broadleaf, 2^{o}Kh, cedar, silver pine, pink pine)	D, heavily logged, shrub margins, heavily grazed	8	CBDB	65	Variable community, (like r37); fenced off from rest of Ruru block except for N boundary; 1 fernbird recorded on SE edge; r38 adjacent to Bell Hill scenic reserve, but separated from it by old Bell Hill (town) to Ruru tramway

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						Ranking	CSI	
r39	0.3	Steep slope incised into Moana outwash tce by Molloys Ck	El: kanuka, toatoa	E	0	DFED	25	Two small patches, adjacent to Farm Settlement boundary fence
r40	15.0	Gully and slopes, some steep, incised by small creek into Loopline morainic hill country	Cl: [miro, rimu, Kh]; kamahi, quintinia, wineberry, toro, broadleaf, (kanuka, 2°Kh)	D, heavily logged, shrub margins heavily grazed	8	CCD:B	63	Vegetation patchy in parts; 1 fernbird recorded, in dense secondary hardwood stand
			El: *Coprosma* spp., 2°Kh, wineberry, marbleleaf, kamahi, toatoa, broadleaf, gorse	E		DFE		
r41	0.2	Alluvial fan, deposited by small tributary of Molloys Ck	El: kanuka, wineberry, toatoa, broadleaf	E, grazed	0	DFED	25	Cleared during 1979-1980
r42	0.3	Moana outwash tce edge, plus slope down to Molloys Ck	El: kanuka, toatoa, (2°Kh, 2°matai, broadleaf)	E, grazed	0	DFED	25	
r43	3.6	a. Moana outwash tce	El: [Kh]; toatoa, 2°Kh, manuka, kamahi, broadleaf	D, heavily logged, shrub parts, grazed, weeds	5	AED:C	60	
		b. Molloys Ck degradational alluvial tce, plus gully opening onto alluvial tce.	A2: [Kh, matai, cedar]; 2°Kh, toatoa, kanuka, (marbleleaf, broadleaf)			AED		
r44	11.5	Degradational alluvial tce system, incised by Molloys Ck into adjacent Moana outwash tce	A2: Kh, matai, (cedar, rimu, miro, H. totara); toatoa, 2°Kh, kanuka, kamahi, broadleaf	D, heavily logged, extensive shrub margins, grazed, weeds	6	ACDC	64	Variable community, patchy in parts; extensive tall shrubs around N edges recently cleared
r45	0.3	Molloys Ck banks and and adjacent degradational alluvial tce	El: kanuka, toatoa, (2°Kh, 2°matai)	E	2	DFED	25	Stand bisected by Molloys Ck tributary
r46	0.1	Loopline morainic slope	Cl: [rimu, miro]; kamahi, toro, 2°rimu, marbleleaf, quintinia, broadleaf	D, heavily logged shrub margins, heavily grazed, weeds	0	CFDD	35	
r47	1.7	Loopline morainic slope	Cl: rimu, miro; kamahi, toro, 2°rimu, quintinia, toatoa, broadleaf	D, logged, shrub margins, heavily grazed, weeds	3	CEDD	40	Entirely fenced off, except for NW boundary; several S. rata trees on S ridge
r48	2.4	Loopline morainic ridge and slopes	Cl: rimu, miro; kamahi, toro, quintinia, 2°rimu, toatoa, 2°miro	D, logged, shrub margins, heavily grazed, weeds	3	CEDD	40	

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status		Notes
						Ranking	CSI	
r49	13.4	Loopline morainic slopes, some steep, plus deeply incised gully	Cl: rimu, miro, (Kh); kamahi, quintinia 2°rimu, toatoa, broadleaf, marbleleaf, wineberry, (2°Kh)	D, logged, shrub margins, grazed, sprayed edges	7	CCDC	54	Variable community, patchy in parts with some shrubby areas
r50	0.7	Steep Loopline morainic slopes	Cl: kamahi, 2°rimu, marbleleaf, quintinia, toatoa, 2°Kh	D, logged, shrub parts, grazed	2	CFDD	35	
r51	0.4	Moana outwash tce	El: kanuka, manuka, toatoa, (2°Kh)	E, heavily grazed	0	DFED	25	
r52	1.1	Small gully incised into Moana outwash tce	Al: matai; toatoa, kanuka, cedar, silver pine, manuka, (2°Kh)	D, logged, shrub margins, grazed	2	AEDD	50	Extensive manuka fringe
r53	3.0	Slight degradational alluvial tce incised by Molloys Ck tributary into adjacent Moana outwash tce	Al: matai, (Kh, cedar); toatoa, kanuka, broadleaf, (H.totara, silver pine, 2°Kh)	D, logged, shrub margins, lightly grazed	5	AEDC	56	Some shrub margins recently cleared
r54	6.2	Degradational alluvial tce system, incised by Molloys Ck tributary into adjacent Moana outwash tce	Al: matai, (Kh); toatoa, kanuka, cedar, broadleaf, kamahi, marbleleaf, 2°Kh, (H. totara, silver pine)	D, logged, shrub margins, grazed	7	AED:C	70	Gorse in El community sprayed, also affecting nearby regenerating native vegetation; red beech outlier, of 8 trees ranging from 15-70cm dbh (plus few seedlings and saplings), located at cliff base below Moana outwash tce (S52:021736)
			A5: RB	A, lightly grazed		AFA		
			El: manuka, kanuka, toatoa, 2°Kh, broadleaf, gorse	E, grazed, sprayed		DEE		
r55	1.2	Moana outwash tce	E2: manuka (2°rimu, 2°Kh, toatoa)	E, grazed	2	EEED	25	Stream and narrow gully, with associated vegetation, on S edge
r56	0.2	Moana outwash tce	El: manuka, toatoa, silver pine, pink pine, 2°Kh	E, grazed	2	DFED	25	
r57	2.0	Narrow degradational alluvial tce, incised by Molloys Ck tributary into adjacent Moana outwash tce	Al: matai; toatoa, kanuka, cedar 2°Kh, (pink pine, H. totara)	D, logged, shrub margins, grazed	3	AEDD	50	Some kanuka and young podocarp regeneration on E & W fringes recently cleared

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Notes
r58	14.4	a. Slight degradational alluvial tce, incised by Molloys Ck tributary into adjacent Moana outwash tce	A2: Kh, matai, cedar, (H. totara); toatoa, kamahi, 2°Kh, kanuka, broadleaf, marbleleaf	D, heavily logged but but regenerating rapidly, lightly grazed	5	AED:C	67	Apart from small clumps of trees and poles, most of E1 community recently flattened and partly burnt, thus dividing r58 in two; RB outlier, of 12 trees ranging from 15-80 cm dbh (plus seedlings and saplings) located on S edge, adjacent to creek (S52: 023722); MB outlier, of 14 small diameter trees, about 100m WSW of R2 stand, isolated from main stands presence of nearby beech stumps, exposed by same shrubland destruction noted above, suggests beech extent formerly much greater, probably encompassing both present stands.
			A5: RB, RBxMB	B, lightly logged (?), grazed		AFB		
			E1; kanuka, 2°Kh, (2°matai, manuka)	E, see notes		DDE		
		b. Moana outwash tce	B5: MB	D, logged(?), shrub margins, grazed		AFD		
r59	7.3	a. Moana morainic ridge and slopes	C1: rimu, miro, (Kh); kamahi, fuchsia, wineberry, broadleaf, (2°Kh, 2°rimu)	D, logged, shrub margins, heavily grazed, weeds	7	CED:C	59	Two fernbirds recorded on NW edge
		b. Moana outwash tce, grading onto morainic toe-slope	B1: Kh, rimu, (H. totara); toatoa, kamahi, marbleleaf, broadleaf, 2°Kh, 2°rimu			AED		
r60	0.3	Moana morainic slope	C1: rimu, Kh, miro; kamahi, (marbleleaf, broadleaf)	D, logged, shrub margins, heavily grazed, weeds	1	CFDD	35	
r61	0.4	Steep slope between Moana moraine and Crooked River alluvial plain	C1: miro, rimu; kamahi, quintinia, marbleleaf, (2°Kh, broadleaf)	D, logged, heavily grazed	4	CFDC	42	
r62	2.6	Steep slopes in gully, and between Moana moraine and Crooked River alluvial plain	C1: miro, rimu, (Kh); kamahi, quintinia, marbleleaf, mahoe, fuchsia, wineberry	D, logged, shrub margins, heavily grazed, weeds	4	CEDC	46	
r63	1.3	Low Moana morainic ridge and slopes	C1: rimu; kamahi, quintinia, toatoa, marbleleaf, wineberry, (2°rimu, 2°miro)	D, logged, heavily grazed, sprayed edges	4	CEDC	46	Poorly drained depression in centre, with some dying rimu trees

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status		Notes
						Ranking	CSI	
r64	0.3	Moana morainic ridge and slopes	C1: [rimu, miro]; kamahi, quintinia marbleleaf, 2°rimu, 2°miro, (2°Kh)	D, logged, heavily grazed, sprayed edges	2	CFDD	35	
r65	57.0	Moana morainic ridges and slopes (aspect predominantly S), plus gullies	C1: rimu, miro; kamahi, quintinia, pokaka, marbleleaf, broadleaf, toro, wineberry, fuchsia, 2°rimu, 2°miro, 2°Kh	D, logged, shrub margins, lightly grazed (except edges) bisecting track and fenceline, old logging tracks	7	CADC	63	Variable community, patchy in parts; haul lines and tracks indicate more recent (?re-) logging; Farm Settlement boundary fence on S edge; kiwi-like probes found at S52: 023705 (see Appendix 4)
r66	0.1	Moana morainic hill slope	C1: kamahi, 2°rimu, broadleaf, (2°Kh)	D, logged, heavily grazed, weeds	2	CFDD	35	
r67	0.3	Slight Moana morainic hill slope, poorly drained	C2: 2°Kh, kamahi, broadleaf, (toatoa, quintinia, rimu, silver pine)	D, logged, heavily grazed, weeds	3	DFDD	30	
r68	0.1	Slight Moana morainic hill slope, poorly drained	C2: 2°Kh, toatoa, silver pine, kanuka	D, logged, heavily grazed, weeds	0	DFDD	30	
r69	0.2	Slight Moana morainic hill slope, poorly drained	C2: [Kh, miro]; 2°Kh, 2°rimu, toatoa, kamahi, (broadleaf, pokaka)	D, logged, grazed, weeds	3	DFDD	30	
r70	0.3	Loopline morainic slope	C1: kamahi, toro, 2°rimu, 2°miro, quintinia, fuchsia, wineberry, toatoa	D, heavily logged and grazed, weeds	3	CFDD	35	
r71	0.6	Loopline morainic slope	C1: [rimu]; kamahi, toro, quintinia, 2°rimu, wineberry, fuchsia, 2°miro	D, logged, heavily grazed, weeds	1	CFDD	35	
r72	1.3	Loopline morainic ridge and slopes	C1: [rimu, miro]; kamahi, toro, quintinia, wineberry, fuchsia, marbleleaf, toatoa	D, logged, heavily grazed, weeds	3	CEDD	40	Old tramline runs through SE corner
r73	2.0	Loopline morainic slopes, plus gully incised by small creek	C1: [rimu, miro]; kamahi, broadleaf, 2°rimu, wineberry, quintinia, toatoa, fuchsia	D, logged, heavily grazed, weeds	3	CEDD	40	
r74	0.8	Steep Loopline morainic slope	C1: rimu, miro; kamahi, toatoa, 2°rimu, quintinia	D, logged, heavily grazed	2*	CFD	39	

Stand No.	Area (ha)	Landform	Plant Community, and Major Emergent and Canopy, or Canopy and Sub-canopy Species	Modification	Birds	Conservation Status Ranking	CSI	Notes
r75	7.0	Steep Loopline morainic slope, plus gully incised by small creek	C1: [rimu, (miro,Kh)]; kamahi, quintinia, 2°rimu, 2°miro, broadleaf, toatoa, pokaka, 2°Kh	D, logged, grazed	4	CDDC	50	Almost completely fenced
r76	47.6	a. Loopline morainic hill country ridges and slopes	C1v: rimu, miro, (Kh); kamahi, quintinia, toatoa, pokaka, broadleaf, toro	A, lightly logged(?)	12	CDA:A	83	Adjacent to Bell Hill Scenic Reserve, of which about 12 ha lie between r76 and Kotuku – Bell Hill Road; this block completely fenced off, although roadside fence in poor condition; haul lines indicate more (?re-) logging of B1 community and lower parts of adjacent C1 community; one fernbird recorded in B1 community (winter 1980)
			C1: rimu, miro, (Kh, cedar); kamahi, toro, quintinia, toatoa, wineberry, marbleleaf, (silver pine, manuka, pink pine)	C, logged, wild animals		CBC		
			C2: 2°Kh	E, logged(?), burnt		DEE		
		b. Small tce, poorly drained	B1: Kh, rimu, cedar, (silver pine); [manuka, broadleaf]	D, heavily logged, lightly grazed, ponded water inhibiting regeneration		AED		
r77	0.3	Loopline morainic ridge	C1: miro, rimu; kamahi, quintinia, 2°rimu, 2°Kh, toatoa, kanuka	D, logged, heavily grazed, weeds	3	CFDD	35	
r79	43.5	a. Loopline morainic ridges and slopes, plus large incised gully	C1: miro, rimu, (Kh); kamahi, quintinia, 2°rimu, toatoa, wineberry, (toro, 2°Kh)	D, logged (varying intensity), shrub margins, grazed	8	CAD:B	71	Highly variable community, including small shrubland areas; group of S. rata trees on ridge (S52: 058734); haul lines in S indicate more recent (?re-) logging; currently fenced except for S boundary; r78 linked to r76 by some kanuka shrubland
		b. Slight Loopline morainic hill slopes, poorly drained	C2: 2°Kh, (2°rimu, toatoa, gorse)	E, burnt(?), grazed, gorse parts sprayed		DEE		
r79	3.7	Steep Loopline morainic slope	C1: [rimu, miro, Kh]; kamahi, quintinia, toatoa, 2°rimu, 2°Kh	D, heavily logged, extensive shrub margins, grazed, edges sprayed	5	CEDC	46	One pair of fernbirds recorded on S edge
r80	14.4	Loopline morainic ridge and slopes, grading down to Moana outwash tce	C1: rimu, miro, (Kh); kamahi, quintinia, 2°rimu, 2°Kh, toatoa, pokaka	D, logged, shrub margins, grazed	5	CCDC	54	S & W boundaries fenced
r81	12.5	Moana outwash tce, partly planed down by meandering Molloys Ck tributary	B1: rimu, Kh, miro, cedar, H. totara, (matai, silver pine); toatoa, 2°Kh, kamahi, broadleaf, marbleleaf, wineberry, kanuka	D, heavily logged, extensive shrub margins, grazed	3	ACD:D	59	Haul lines indicate part more recently (?re-) logged
			E2: manuka, *Coprosma* spp.	E, grazed		EEE		

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						Ranking	CSI	
r82	1.9	Moana outwash tce, bisected by Molloys Ck tributary	Bl: Kh, rimu, miro, (cedar, H.totara), toatoa, kamahi, 2°Kh, 2°rimu, wineberry, broadleaf, (kanuka, gorse)	D, heavily logged, shrub margins, grazed, sprayed edges	2	AEDD	50	
r83	0.6	Moana outwash tce; small creek on S edge	Bl: [rimu, Kh, H.totara, matai]; 2°Kh, toatoa, marbleleaf, broadleaf, (2°matai, 2°rimu, cedar, silver pine)	D, heavily logged, shrub margins, grazed, sprayed edges	2	AFDD	45	
r84	0.1	Moana outwash tce; small creek on S edge	Bl: [rimu, Kh]; 2°Kh, (marbleleaf)	D, logged, grazed	2	AFDD	45	
r85	0.7	a. Moana outwash tce	Bl: [rimu, miro]; 2°Kh, kamahi, toatoa	D, logged, shrub margins, grazed	4	AFD:C	55	Partly a small hill, apparently of moranic origin, rising above surrounding Moana outwash tce
		b. Loopline (?) morainic rise	Cl: [rimu]; kamahi, toatoa, wineberry, fuchsia, quintinia			CFD		
r86	5.7	Loopline (?) morainic rise	Cl: miro, rimu; kamahi, quintinia, broadleaf, toatoa, 2°rimu, (2°miro, 2°Kh)	D, logged, shrub margins, grazed	4	CDDC	50	Hill, apparently of morainic origin, rising above surrounding outwash tce
r87	0.1	Moana outwash tce, bisected by small stream	Bl: marbleleaf, kamahi, broadleaf, 2°Kh, 2°rimu, 2°miro	D, heavily logged and grazed, weeds	1	AFDD	45	
r88	1.0	Low morainic ridge on Moana outwash tce	Cl: miro, Kh; 2°Kh, kamahi C2: 2°Kh, kamahi	D, logged, shrub parts, grazed	1	CFD:D DFD	39	
r89	1.5	Moana outwash tce, bisected by small creek	Bl: [Kh, miro]; kamahi, wineberry, quintinia, marbleleaf, fuchsia, 2°rimu	D, logged, heavily grazed	5	AEDC	56	
r90	0.2	Moana outwash tce	Bl: kamahi, marbleleaf, fuchsia, broadleaf, 2°Kh	D, heavily logged and grazed	0	AFDD	45	
r91	0.2	Low morainic ridge on Moana outwash tce	Cl: [rimu]; kamahi, marbleleaf, 2°rimu, 2°Kh, fuchsia	D, logged, heavily grazed	0	CFDD	35	
r92	0.3	Low morainic ridge on Moana outwash tce	Cl: [rimu, Kh]; kamahi, 2°Kh	D, logged, heavily grazed	3	CFDD	35	
r93	1.0	Low morainic ridge on Moana outwash tce	Cl: miro, rimu, Kh; kamahi, quintinia, 2°rimu, 2°Kh, (silver pine)	D, logged, shrub margins, grazed, weeds, bisecting drain	6	CEDC	46	

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						Ranking	CSI	
r94	13.7	Rolling Moana morainic slopes	C1: [miro, rimu, (Kh)]; kamahi, quintinia, toatoa, 2°rimu, 2°miro 2°Kh	D, logged, shrub parts, grazed	7	CCDC	54	Variable community, including some shrubland areas; haul lines and tracks suggest more recent (?re-)logging
r95	0.7	Moana morainic ridge	C1: miro, (rimu, Kh); kamahi, quintinia, 2°rimu, 2°Kh, toatoa	D, logged, heavily grazed, weeds	3	CFDD	35	
r96	0.5	Slight depression in rolling Moana morainic country	E1: manuka, kanuka, toatoa, silver pine, 2°rimu	E, grazed, weeds	2	DFED	25	
r97	0.7	Slight Moana morainic hill slope	B6: RB, MB, (RBxMB); [kamahi, toatoa, H. totara]	B, lightly logged, shrub margins, grazed, bisected by drain, sprayed edges	3	AFBD	55	Beech expanding into shrubland fringes
r98	0.2	Small gullies in rolling Moana morainic country	E2: maunuka, *Coprosma* spp.	E, grazed	0	EFED	20	
r99	0.5	Gully in rolling Moana morainic country	E2: manuka, gorse, *Coprosma* spp.	E, grazed	0	EFED	20	
r100	0.3	Moana morainic slopes	E2: manuka	E, grazed	0	EFED	20	
r101	0.3	Slight Moana morainic slopes	E2: manuka, gorse, *Coprosma* spp.	E, grazed	0	EFED	20	
r102	6.9	Moana morainic slopes	B6: RB, (rimu, Kh, H. totara, miro, MB); 2°RB, 2°MB, kamahi, toatoa	B, lightly logged, extensive shrub margins, heavily grazed	5	ADB:C	71	Much variation in beech stands, with regenerating MB and RB dominant on most edges; beech now expanding into shrubland fringes; charred beech stumps in vicinity indicate this beech outlier formerly of much greater extent, and linked with beech in r97 & r103
			E2: manuka, gorse	E, grazed		EEE		
r103	7.1	a. Moana morainic ridge and slopes	C1: miro, rimu; kamahi, quintinia, toatoa, broadleaf, marbleleaf, 2°rimu	D, logged, shrub margins, grazed	7	CED:C	70	For general notes re beech, see r102; new fence isolates SW "arm"; stand contains valuable relatively intact beech-podocarp boundary
		b. Moana outwash tce and slight morainic slopes	B6: RB, MB, (RBxMB, Kh, rimu, miro) [kamahi, H. totara]	B, lightly logged, shrub margins, grazed		AEB		
			B1: Kh; 2°Kh, 2°rimu, toatoa, kamahi, (2°matai, pink pine, silver pine)	D, logged, shrub margins, grazed		AED		
r104	1.0	Moana morainic toe-slope	C1: miro, Kh; quintinia, kamahi, 2°Kh, 2° rimu, (broadleaf, toatoa)	D, logged, shrub margins, heavily grazed, weeds, sprayed edges	5	CEDC	46	

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						Ranking	CSI	
r105	23.2	a. Slight degradational alluvial tce, incised by Molloys Ck tributary into Moana outwash tce	A1: [matai]; 2°Kh, toatoa, kanuka, (kamahi, broadleaf, 2°rimu)	D, heavily logged, extensive shrub	6	AED:C	71	Stand bisected by farm track; 4 fernbirds recorded on E edges
			A4: [Kh, rimu, (miro, cedar, matai)]; 2°Kh, kamahi, kanuka, marbleleaf, toatoa	margins, grazed, weeds, sprayed		BCD		
		b. Slopes between creek and Moana outwash tce	C1: [rimu, miro]; kamahi, quintinia, toatoa			CED		
		c. Moana outwash tce	B2(i): rimu, (Kh, miro); [kamahi, toatoa, quintinia, 2°Kh]	B, lightly logged, grazed		AEB		
			B2(ii): [rimu, Kh, (miro)]; toatoa, kamahi, quintinia, (broadleaf)	D, heavily logged, grazed		AED		
			E2: manuka, (gorse, toatoa)	E, grazed		EEE		
r106	3.3	Slight degradational alluvial tce, incised by Molloys Ck tributary into adjacent Moana outwash tce	A2: [Kh, matai, (cedar)]; 2°Kh, toatoa, kanuka, manuka, (pink pine, wineberry, broadleaf)	D, heavily logged, shrub margins lightly grazed	6	AEDC	56	Drain on S edge
r107	0.3	Moana outwash tce	B1: Kh, rimu, (miro); 2°Kh, kamahi, toatoa	D, logged, grazed	0	AFDD	45	
r108	1.9	Moana outwash tce	B1: [Kh, rimu, miro]; 2°Kh, 2°rimu, kamahi, (quintinia, toatoa, silver pine, broadleaf)	D, logged, grazed, bisecting drain	6	AEDC	56	